RAFFERTY-ALAMEDA PROJECT

ENVIRONMENTAL IMPACT STATEMENT

Souris Basin Development Authority

CHAPTER 13

IRRIGATION

RAFFERTY/ALAMEDA ENVIRONMENTAL IMPACT STATEMENT

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IRRIGATION

INTRODUCTION

The construction of Rafferty and Alameda Reservoirs will create potential for new irrigation development in the Souris River Basin. The nature of this future development is dependent upon a range of factors. These include availability of land suitable for irrigation; availability of water for irrigation, and the relative economic merit of irrigation under various development scenarios. A recent study commissioned by the Saskatchewan Water Corporation undertook a conceptual evaluation of irrigation costs and benefits associated with Rafferty and Alameda Reservoirs (Water Resource Consultants, 1985). The contents of this study have been interpreted with respect to defining the extent and probability of irrigation development.

Evaluation of land suitability for irrigation was undertaken for three areas: townships surrounding the Rafferty Reservoir; townships surrounding the Alameda Reservoir; and the Souris River Valley bottom lands between the Rafferty dam and the U.S. Border.

Computer modeling by the Saskatchewan Water Corporation provided estimates of 32,000 dam^3 of water available for irrigation seven out of ten years. This initial modeling assumed a 50 percent evaporation credit towards U.S. apportionment for net evaporation loss on the two reservoirs. Based on the crop water requirements in the Project Area, a maximum potential of 7,200 hectares (approximately 18,000 acres) was assumed to be irrigable. This modeling assumed 3,200 hectares (8,000 acres) downstream Souris Valley lowlands would be irrigated from Rafferty and 4,000 ha (10,000 acres) of uplands would be irrigated adjacent to the Alameda Reservoir.

Since those earlier estimates were made, there have been a number of significant changes to the hydrologic modeling. These include an evaporation credit to Saskatchewan, relocation of the Rafferty dam, changes to the operating levels of the Rafferty reservoir, inclusion of the Boundary to Rafferty diversion channel, and a decision by Saskatchewan Power Corporation to propose wet-cooling of two 300 megawatt power generating units using water from Rafferty and effluent from the Estevan Sewage Lagoons. Coupled with the Authority's intent to maximize the summer season recreation potential of the

Rafferty reservoir and the anticipated slower development of upland irrigation, these changes have resulted in the development of a reduced but more effective irrigation scenario. Recognizing the multiple objectives of the Rafferty/Alameda Project, the Authority, together with Saskatchewan Power Corporation and the Saskatchewan Water Corporation, chose to model future potential irrigation at a maximum of 4,800 ha (12,000 acres) rather than the earlier estimate of 7,200 ha (18,000 acres).

The results of modeling with 4,800 ha of irrigation are described in the Hydrology Section of this Environmental Impact Statement. As the reservoirs are sensitive to irrigation withdrawals, this downward adjustment in irrigated acreage made a significant improvement to the projected long-term and annual reservoir fluctuations during the summer recreation seasons. The Authority considers the current proposal as an optimization of the benefits, considering all potential water users as well as short-term and long-term returns on investments. The following irrigation discussion documents the rationale leading to this conclusion.

BACKGROUND

The purpose of a Water Resource Consultants Ltd. (WRC) Study (December, 1985) commissioned by the Saskatchewan Water Corporation was to investigate the potential for positive benefits that might be achieved from the Rafferty and Alameda reservoirs. The Study examined the feasibility and economics of utilizing the capacity of the reservoirs for irrigation as well as other purposes. The irrigation component of the WRC Study was based upon generally available soil classification data; specific field surveys t confirm previous background data were not undertaken. Several different irrigation scenarios were examined from an economic viewpoint.

A key objective of the WRC Study was to define the costs and benefits of new irrigation development that could be supplied from the Rafferty and Alameda Reservoirs. The analysis was based on soil classifications, water requirement determinations, conceptual designs and cost estimates and subsequent economic analysis. The soil classification component identified areas with soils and topography suitable for irrigation development. The water requirement analysis, conceptual design studies and cost estimates confirmed the

feasibility of supplying water to blocks of lands around the perimeters of both reservoirs and along the Souris River Valley lowlands downstream from the reservoirs.

The 1985 WRC Study made extensive use of existing information such as the 1978 Souris River Basin Study, more recent Saskatchewan Power Corporation studies undertaken by Cochrane Lavalin and the Saskatchewan Water Corporation/UMA Engineering studies related to economic appraisals of eight irrigation areas in the province. Prairie Farm Rehabilitation Administration (PFRA) Hydrology Division provided computer water balance models to examine six selected scenarios to provide estimates of the maximum, minimum and average amounts of water that could be made available for irrigation development. Firm annual drafts (100%) as well as water yields that could be made available for irrigation 70 percent of the time were analyzed.

CIRCUMSTANCES

The climate in the Study Area is generally semi-arid; the growing season averages 175 days and the frost-free period is between 90 and 110 days, averaging approximately 100 days. Typical of a continental climate, the temperature ranges from summer highs in excess of 38½C to mid-winter lows of -40½C with a mean annual of about 4½C.

Average annual precipitation ranges from 380 mm in the southern parts to 455 mm in the northern higher parts of the Study Area, with the majority (60%) occurring during the growing period, May through September.

As described in the Soils section of this Environmental Impact Statement, three major soils group are contained in the Study Area. The dominant upland soils group includes both dark brown and black chernozemic grassland soils with generally a loamy texture ranging from sandy loam to silty clay loam. Regosolic soils which are weakly developed, undifferentiated soils occur along the Souris River Valley bottom lands.

North of Weyburn at the edge of the Regina Plains, the soils are generally clay, heavy clay or clay loam in texture and are not well suited to irrigation because of their clayey texture and the solonetzic soil profiles of the Tuxford and Estevan Associations.

In the Rafferty Project Area, and generally from Weyburn to near Oxbow the Souris spillway eroded glacial till soils 3 km to 5 km wide on both sides of the Souris River. The upland soils adjacent to the wide Souris spillway are variable with the most common types loam to sandy loam soils of the Weyburn and Forget Associations, course to medium textured fluvial and lacustrine soils over till, and the resorted till of the Estevan Association. Salinity is relatively common, particularly near Weyburn and west of Midale. South of Estevan, some small areas of Asquith fine loams may be considered as some of the better soils for irrigation.

The frequent occurrence of Solonetzic soils and the almost general occurrence of saline subsoil at depths of 1 m to 1.25 m are the strongest deterent to irrigation. Salinity is particularly common in many soils occurring in lacustrine deposits overlying glacial till, along streamways and in low lying areas (WRCL 1985).

The best soils for irrigation are the Forget sandy loams and the Weyburn loams located on both the north and south sides of the Souris River about halfway between Weyburn and Estevan (Figure 1). In Township 3, Range 10 these better soils for irrigation are nearest the Rafferty Reservoir.

In the Alameda Project Area the soils are generally sandy loam or loamy sand over gravel, part of the Meota and Whitesand Associations. The irrigation suitability of the sandy and gravelly soils is limited because of their texture and the frequent occurrence of saline soils, particularly near smaller streams. Further from the drainage courses, loamy textured till soils of the Oxbow Association occur on a gently to roughly undulating till plains. The Oxbow soils are the best suited soil for irrigation in the Alameda area but saline subsoils can be encountered there as well at about 1 m depths. Figure 2 illustrates the location of the best soils for irrigation in the Alameda Project Area.

POTENTIAL IRRIGATION DEVELOPMENT

The analysis was carried out with the help of various inter-linked models. In brief, the farm simulation model was run for a typical dryland farm, as well as for an average irrigated grain farm, an irrigated livestock farm and forage operation, and an irrigated specialty crop farm. The information generated was

RGE. 14
RGE. 13
RGE. 12
RGE. 11
TWP 8
TWP 7
TWP 6
TWP 5
WEYBURN
RALPH
HALBRITE
GOODWATER
MIDALE
30
701

FIGURE 1

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SOURIS BASIN DEVELOPMENT AUTHORITY

RAFFERTY / ALAMEDA PROJECTS

RAFFERTY DAM
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ENVIRONMENTAL IMPACT STATEMENT
IRRIGATION CAPABILITY

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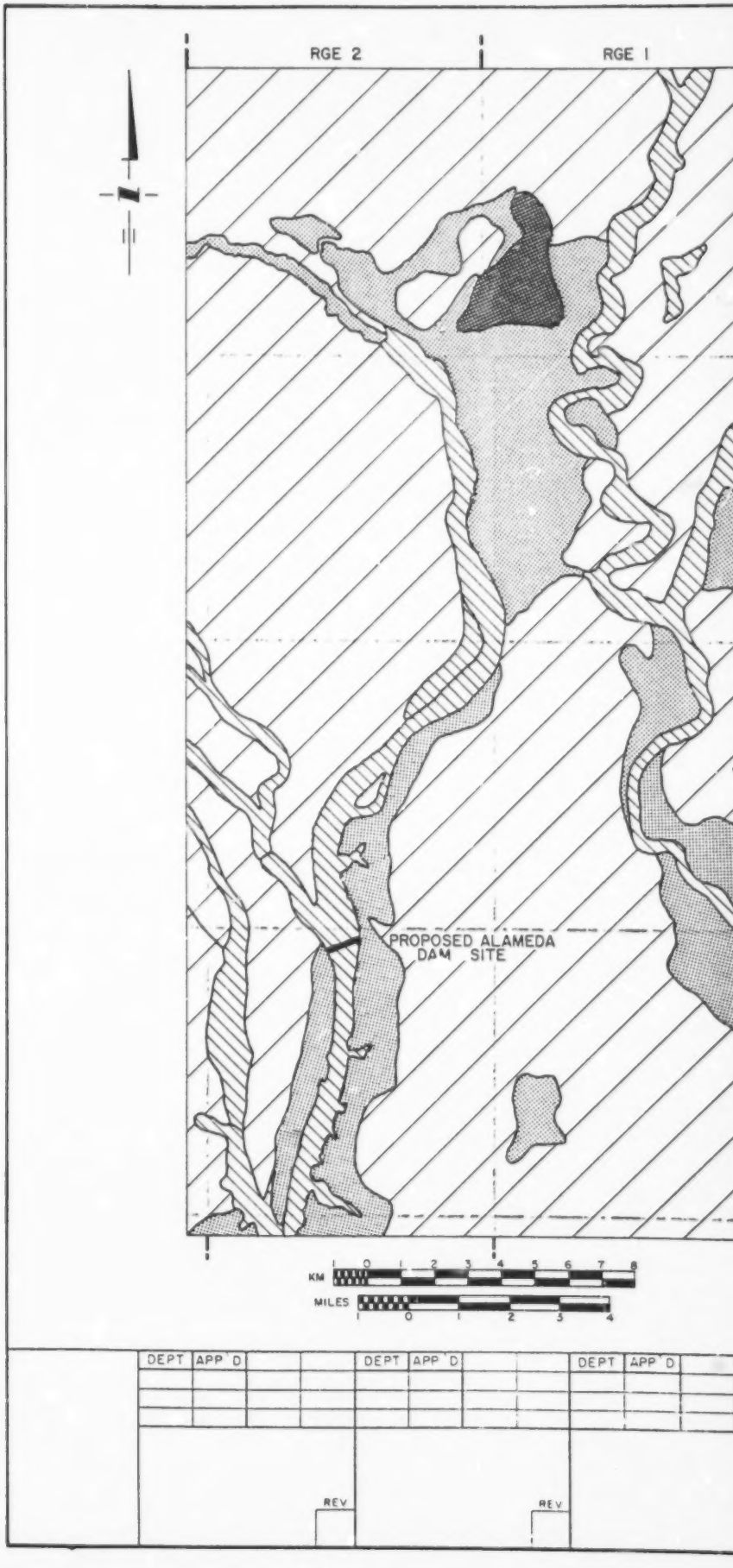
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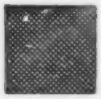
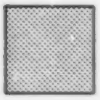


CLASS 1 – EXCELLENT; VERY WELL SUITED FOR IRRIGATION

CLASS 2 – GOOD; WELL SUITED FOR IRRIGATION



CLASS 3 – FAIR; ACCEPTABLY SUITED FOR IRRIGATION

CLASS 4 – POOR; UNSUITED FOR IRRIGATION DUE TO FLOODING, SALINITY, STEEP SLOPES, etc.

FIGURE 2

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SOURIS BASIN DEVELOPMENT AUTHORITY

RAFFERTY / ALAMEDA PROJECTS

ALAMEDA DAM
RESERVOIR
ENVIRONMENTAL IMPACT STATEMENT
IRRIGATION CAPABILITY

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used to assess the gross and net benefits to the water users of converting an area of dryland farming into irrigated production, using a variety of crops.

The analysis was divided into various phases. The construction phase, for example, was separated from the irrigation operations phase. An uptake rate of ten years was selected, after the reservoirs reach the minimum operating levels suitable for irrigation withdrawals. Ten years was deemed to be reasonable considering that it will likely take five to ten years for the reservoirs to reach working supply levels and, further, that the total area proposed for irrigation development is much less extensive than that in the Lake Diefenbaker-Outlook area. For any upland irrigation blocks near the Alameda reservoir, construction of a main pumping station would take up to two years, and distribution canals or pipelines up to four or five years. Upland irrigation could be commenced as soon as water is available if main irrigation works were being constructed during the initial reservoir filling period. Realistically, non-intensive irrigation in the Souris River Valley will develop before the intensive and much more costly upland irrigation.

CURRENT IRRIGATION DEVELOPMENT

As described in the Land Use Section, there is presently very little irrigation undertaken in the Study Area. Forty-five farms, representing 1.4 percent of the total provincial irrigated area, reported irrigation of 792.8 ha in 1981 (Canada Census Divisions 1 and 2). The average irrigated area was 17.8 ha (44 acres) compared to a provincial average of 43.7 ha (108 acres).

Sprinkler irrigation was reported by 27 farms on 416.4 ha (1,029 acres) in the Study Area (Census Divisions 1 and 2, 1981) but only nine of these were in the Rafferty Project Area. Two were reported in the R.M. of Lomond, two in the R.M. of Weyburn and five in the R.M. of Estevan.

Based on the 1981 Census, irrigation farming in the Study Area is concentrated in the R.M. of Estevan where 8 farms reported irrigating 263 ha (650 acres). Three of these farms irrigated 238.8 ha (590 acres) by non-sprinkler methods while the other five farms irrigated the remaining 24.2 ha (60 acres).

Within the Study Area only between six and seven farms out of every 1,000 irrigate; this compares to a provincial rate of 20 per 1,000.

Elsewhere in the Souris Basin, a number of smaller reservoirs have been developed, some for irrigation as well as stock watering and municipal water supplies. These include Roughbark Reservoir in the upper reaches of Roughbark Creek, Dead Lake, an off stream reservoir along the Souris River south of Midale, and Moose Mountain Lake in the upper reaches of Moose Mountain Creek. All three were constructed in 1937. Three other reservoirs were constructed on Long Creek between 1949 and 1958: Maxim Lake, Larsen Reservoir and Boundary Reservoir. Weyburn Reservoir (now Albert Douglas Reservoir or Nickle Lake) was constructed on the Souris River as a municipal water supply and subsequently enlarged in 1983.

WATER AVAILABILITY

The main stem of the Souris and two principal tributaries in Saskatchewan each contribute approximately one-third of the total flow volume at the International Boundary. Over the 52 year flow record period (1930-1981), WRC determined that 82 percent of the total mean annual flow at that point occurred as spring runoff. In addition, the minimum and maximum annual recorded flow volumes were approximately 1,400 dam^3 in 1937 and 780,000 dam^3 in 1976. On many occasions the minimum flows were zero. These extreme variations in stream flow, without adequate impoundments for storage, indicate the unreliability of the Souris River system as a source of irrigation water. The Rafferty and Alameda reservoirs will store water during years of above average stream flow (especially during floods) for use during years of below average natural stream flow.

Forty to fifty percent (48,000 to 60,000 dam^3) of the natural streamflow (120,000 dam^3) must be passed to the United States. Saskatchewan's inability to store and use its share of the water, has facilitated North Dakota's ability to turn the majority of all waters originating in the Saskatchewan portion of the Souris Basin to U.S. advantage.

WATER DEVELOPMENT SCENARIOS

The water supply alternatives considered by WRC included Rafferty Reservoir, Alameda Reservoir, the diversion channel between Boundary and Rafferty reservoirs, and groundwater from the aquifers. Each of these alternatives plus various combinations were considered. The computer methodology included numerous hydrologic factors including: natural stream flow data on the Souris River and tributaries for the period 1912-1981; updating water demands; historic meteorologic data; area/capacity curves for proposed reservoirs; evaporation related to surface areas; near future, foreseeable and far future water requirements; Rafferty water requirements for the proposed Shand Power Station; various diversion channel capacities; make-up water from Rafferty to Boundary Reservoir during low flow periods on Long Creek; and operating the reservoirs to meet international downstream commitments.

The WRC initial study findings determined that a maximum of 7,500 cubic decametres (dam^3) of firm (100%) annual water yields could be provided for irrigation when considering both reservoirs, the diversion channel, foreseeable future water requirements and supplying 5,572 dam^3 annually from Rafferty to the Shand cooling pond. The WRC Study was subsequently broadened to determine whether more water could be made available for irrigation. This investigation involved the feasibility of annual drafts 70 percent of the time. One of the more promising scenarios indicated that 5,630 dam^3 would be available for irrigation 100 percent of the time (3,310 dam^3 from Rafferty and 2,320 dam^3 from Alameda) or 32,970 dam^3 70 percent of the time (13,610 dam^3 from Rafferty and 16,290 dam^3 from Alameda). A number of the other scenarios indicated similar water supplies available for irrigation.

GROUNDWATER

WRC undertook an evaluation of the available groundwater supplies to determine their suitability for irrigation. Previous studies had identified three major aquifers in the Study Area; the Weyburn Valley Aquifer, the Estevan Valley Aquifer and the Ravenscrag Bedrock Formation. Total yields had been estimated at more than 18,000 dam^3 per year (WRC). Water analyses for all

three aquifers indicted total dissolved solids ranging from 1,200 mg/l to 5,000 mg/l, generally far in excess of the acceptable maximum levels for irrigation. These aquifers indicted medium to very high alkalinity hazards and a very high salinity hazard. With salinity already being a potential problem in many of the soils in the Project Area, it was concluded that all groundwater sources are unacceptable for irrigation use.

Studies of projected water quality for both the Rafferty and Alameda Reservoirs were conducted by Cochrane Lavalin. Water from both reservoirs was concluded to be suitable for irrigation. The issue of water quality is dealt with in detail in the Water Quality section of this Environmental Impact Statement. It is to be noted that irrigation and limited return flows were included in the water quality monitoring as it relates to the Souris River downstream at the U.S. border.

SOILS STUDIES

Irrigation suitability of lands adjacent to and downstream from the proposed Rafferty and Alameda reservoirs was assessed. Since water supplies are limited, and costs for water conveyance for upland irrigation increase with distance, land areas investigated were concentrated within those townships on either side of the reservoirs and the Souris Valley bottom lands between the Rafferty Dam site and the International border. (Details of these investigations are in the WRC Report, Appendix C.)

LAND CLASSIFICATION

Two irrigability classification systems were available for wheel roll and centre pivot sprinkler irrigation systems. The system adopted by WRC was developed by a Working Group on Irrigation Classification (Western Canada) by the Expert Committee on Soil Survey (ECSS). It combines information on both soil and landscape into a working matrix involving four classes of land suitability described as excellent (Class 1), good (Class 2), fair (Class 3) and poor (Class 4). A brief description of these four classes is as follows:

Class	Rating	Description
Class 1	Excellent	Lands in this class have no significant limitations for irrigation. The soils are medium textured, well drained, and hold adequate available moisture. Harmful accumulations of soluable salts are absent from the soil and topography is often level or nearly level.
Class 2	Good	Lands in this class have slight limitations for irrigation due to unfavorable characteristics of either the soil or landscape or both. The soils in this class may be heavier or lighter in texture than soils in Class 1.
Class 3	Fair	Lands in this class have moderate limitations for irrigation use due to deficient characteristics of either the soil, the landscape or a combination of both. The soils may be inferior because of excess salinity, sodicity, very low hydraulic conductivity or low water holding capacity. Greater management input as well as more intensive soil conservation and improvement practices are required for this group of soils than for the soils in the Good category.
Class 4	Poor	Lands in this class have severe limitations for irrigation use due to adverse characteristics related to either the soil, the landscape or a combination of both. These lands may have some limited use under irrigation but generally their limitations are so severe that they do not form suitable irrigation-farm units.

The ECSS system resulted in the classification of lands in the immediate vicinity of the Rafferty and Alameda reservoirs and along the Souris River

bottom lands as indicated in Table 1. Figures 1, 2 and 3-1 to 3-5 delineate the areas of each soil classification in these three potential areas. (Further details are available in the WRC Report, Appendix C.)

TABLE 1

Classification of Irrigable Lands (Hectares)

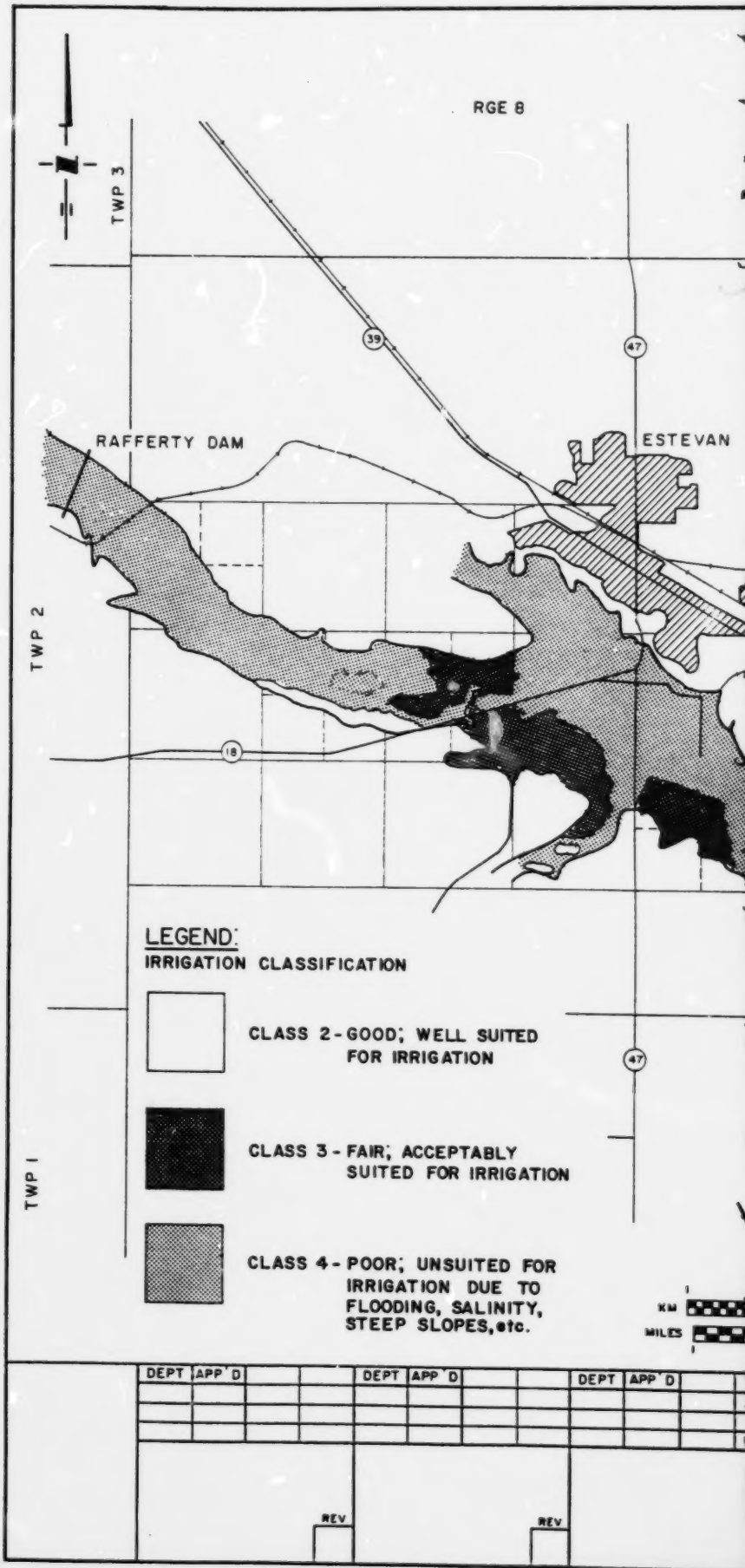
	Surrounding Rafferty Reservoir	Surrounding Alameda Reservoir	Souris River Bottom Lands
Class 1 (excellent)	-	724	-
Class 2 (good)	18,304	30,682	3,846
Class 3 (fair)	109,431	8,808	2,564
Class 4 (poor)	104,692	15,626	607
TOTAL	232,427	55,840	7,017

Source - WRC Report, Volume 1, p.60.

The area of irrigable land (Class 1 to Class 4 inclusive) along the Souris River Valley bottom between the Rafferty dam site and the confluence of Moose Mountain Creek near Oxbow was estimated by WRC to be 4,772 ha (68%). The remaining 2,245 ha of potentially irrigable lowlands (32%) occur between Moose Mountain Creek and the International Border.

Earlier studies by Saskatchewan Agriculture (Bristol, 1973, 1977), estimated that there were about 3,238 ha (8,000 acres) of land potentially good for irrigation. Analytical results from 19 test holes showed the total salts in these alluvial soils to be low, suggesting relatively good drainage. The majority of the Souris valley soils east of Estevan belonged to alluvium mapping unit (Avl) with clay loam to clay soils. As such, they ranged from Class 2 to Class 3 irrigation soils. Where textures grade to a clay, the soils would be rated Class 3 because of the increased potential for drainage and permeability problems.

A subsequent study by Cameron (Normac A.E.S. Ltd., 1986) for the Saskatchewan Water Corporation undertook a more detailed irrigation suitability investigation of the Souris Valley lowlands and the Moose Mountain Creek valley


RGE 8
TWP 3
TWP 2
TWP 1
RAFFERTY DAM
ESTEVAN
39
47
18
47
LEGEND:
IRRIGATION CLASSIFICATION
CLASS 2 - GOOD; WELL SUITED FOR IRRIGATION
CLASS 3 - FAIR; ACCEPTABLY SUITED FOR IRRIGATION
CLASS 4 - POOR; UNSUITED FOR IRRIGATION DUE TO FLOODING, SALINITY, STEEP SLOPES, etc.
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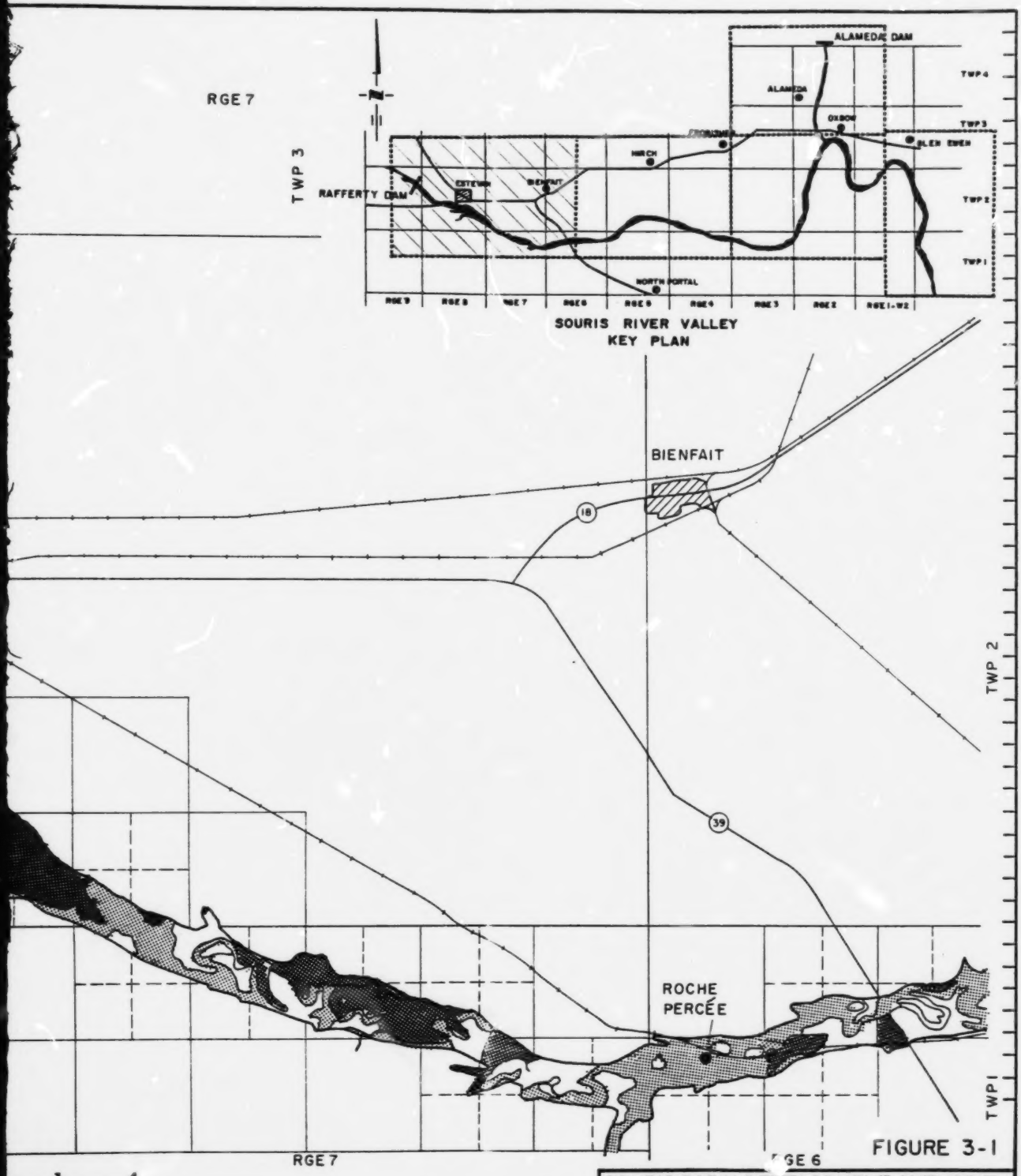

FIGURE 3-1

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SOURIS BASIN DEVELOPMENT AUTHORITY

RAFFERTY / ALAMEDA PROJECTS

RAFFERTY / ALAMEDA DAMS
RESERVOIR
ENVIRONMENTAL IMPACT STATEMENT
IRRIGATION CAPABILITY IN THE
SOURIS RIVER VALLEY

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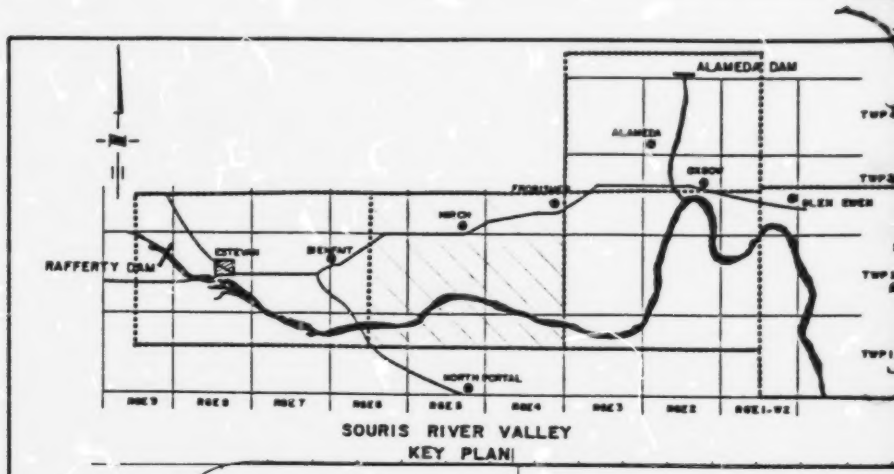
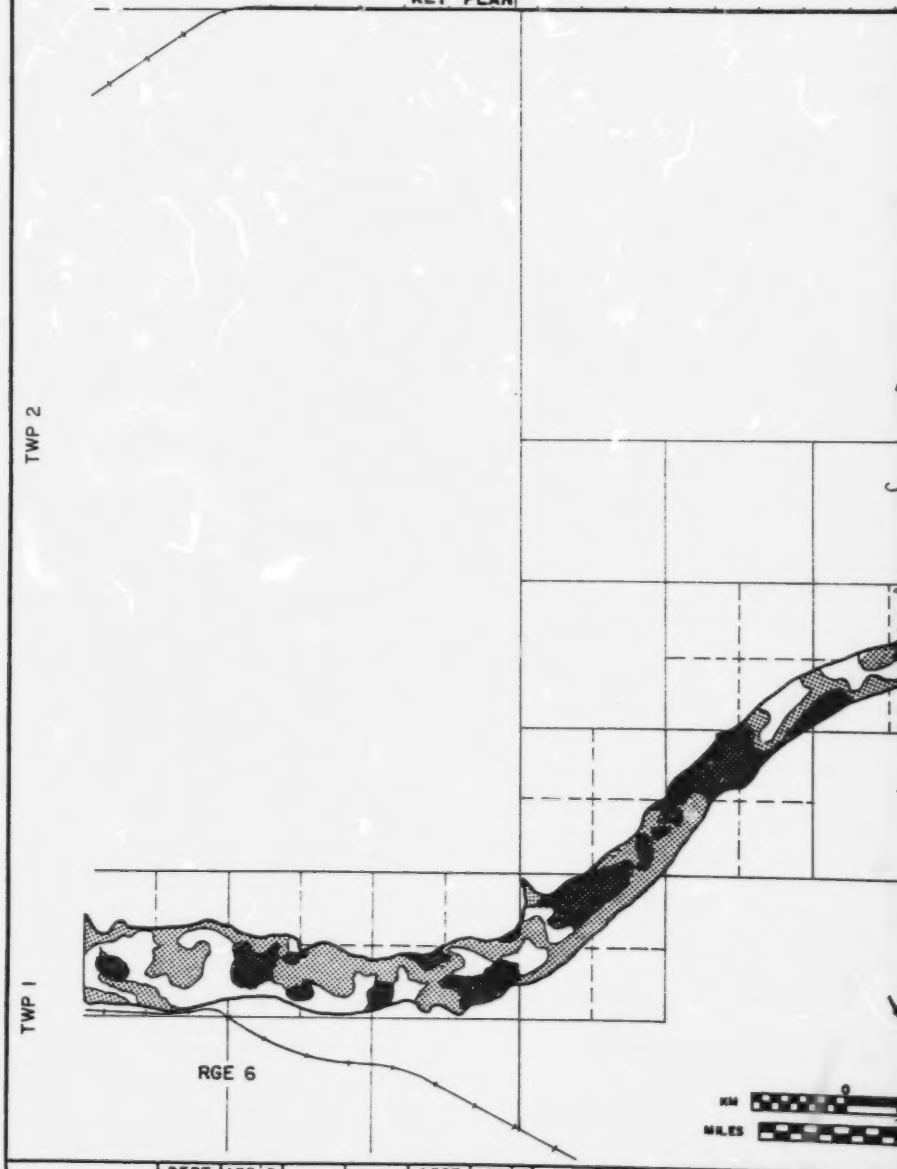


SOURIS RIVER VALLEY
KEY PLAN



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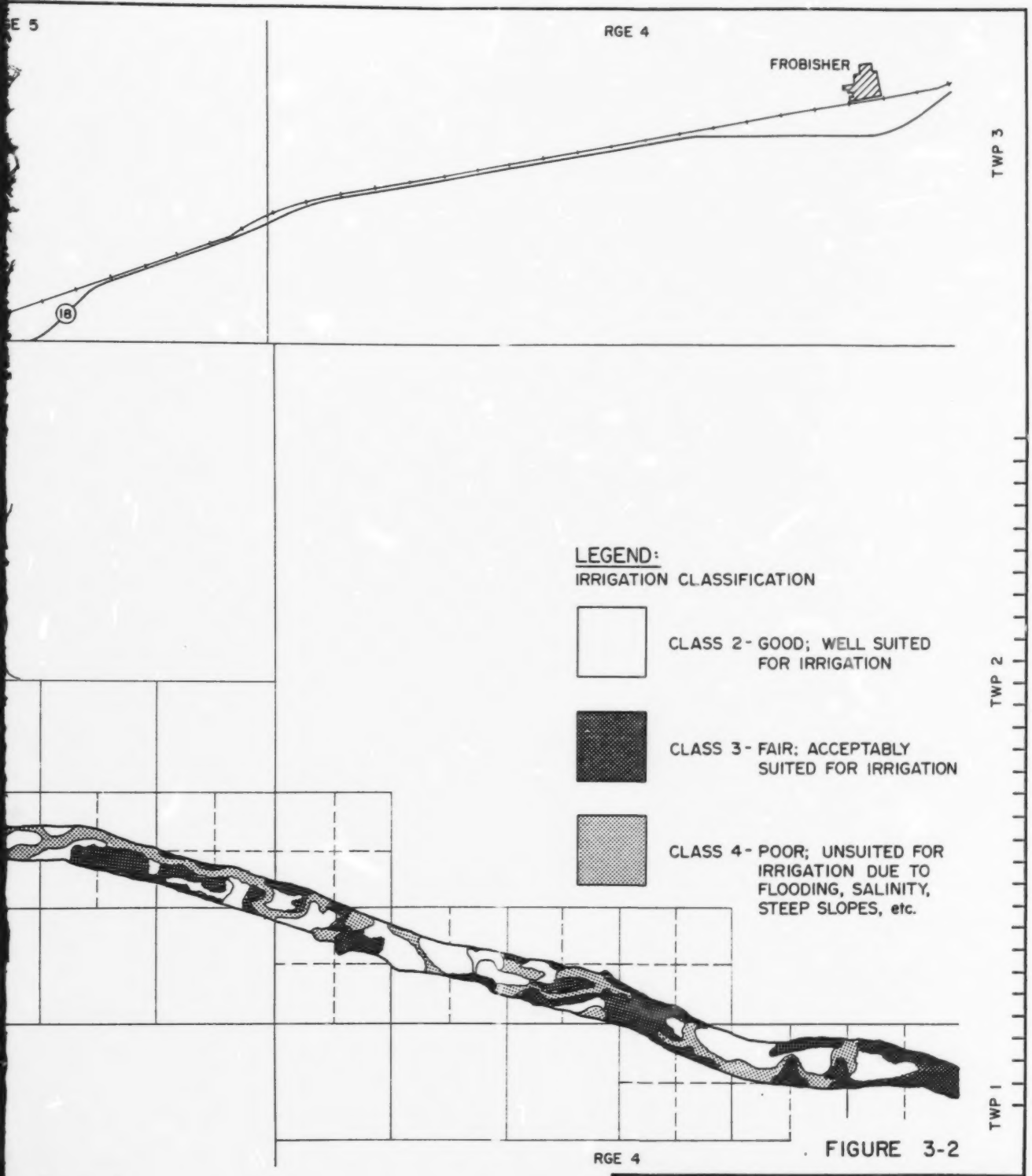

FIGURE 3-2

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SOURIS BASIN DEVELOPMENT AUTHORITY

RAFFERTY / ALAMEDA PROJECTS

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IRRIGATION CAPABILITY IN THE
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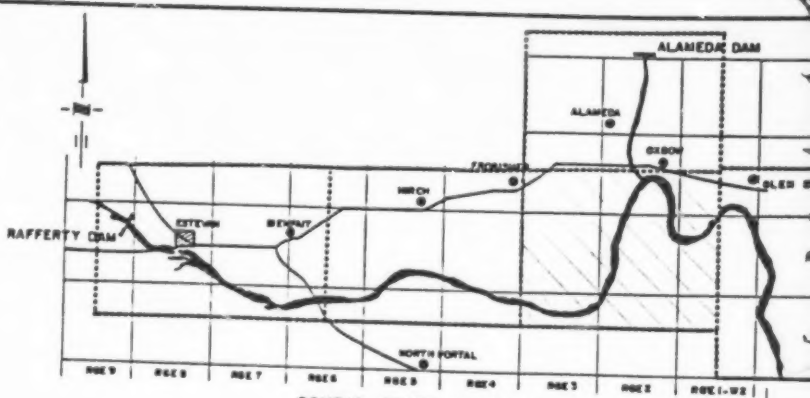

SOURIS RIVER VALLEY
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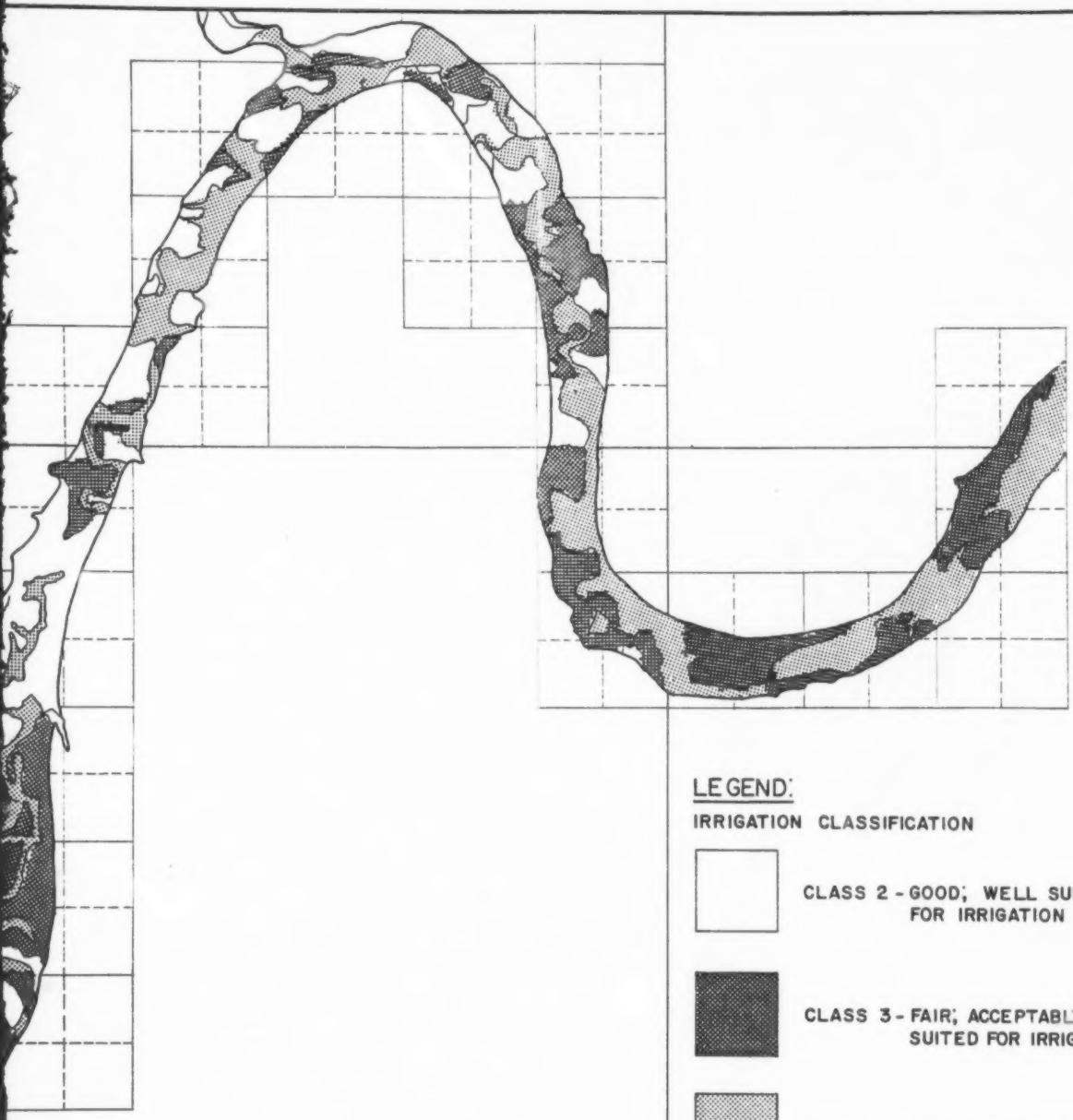


LEGEND:

IRRIGATION CLASSIFICATION

CLASS 2 - GOOD; WELL SUITED FOR IRRIGATION

CLASS 3 - FAIR; ACCEPTABLY SUITED FOR IRRIGATION

CLASS 4 - POOR; UNSUITED FOR IRRIGATION DUE TO FLOODING, SALINITY, STEEP SLOPES, etc.

RGE 2

KM 1 0 1 2 3 4

MILES 1 0 1 2

FIGURE 3-3

DEPT	APP'D

REV

REV

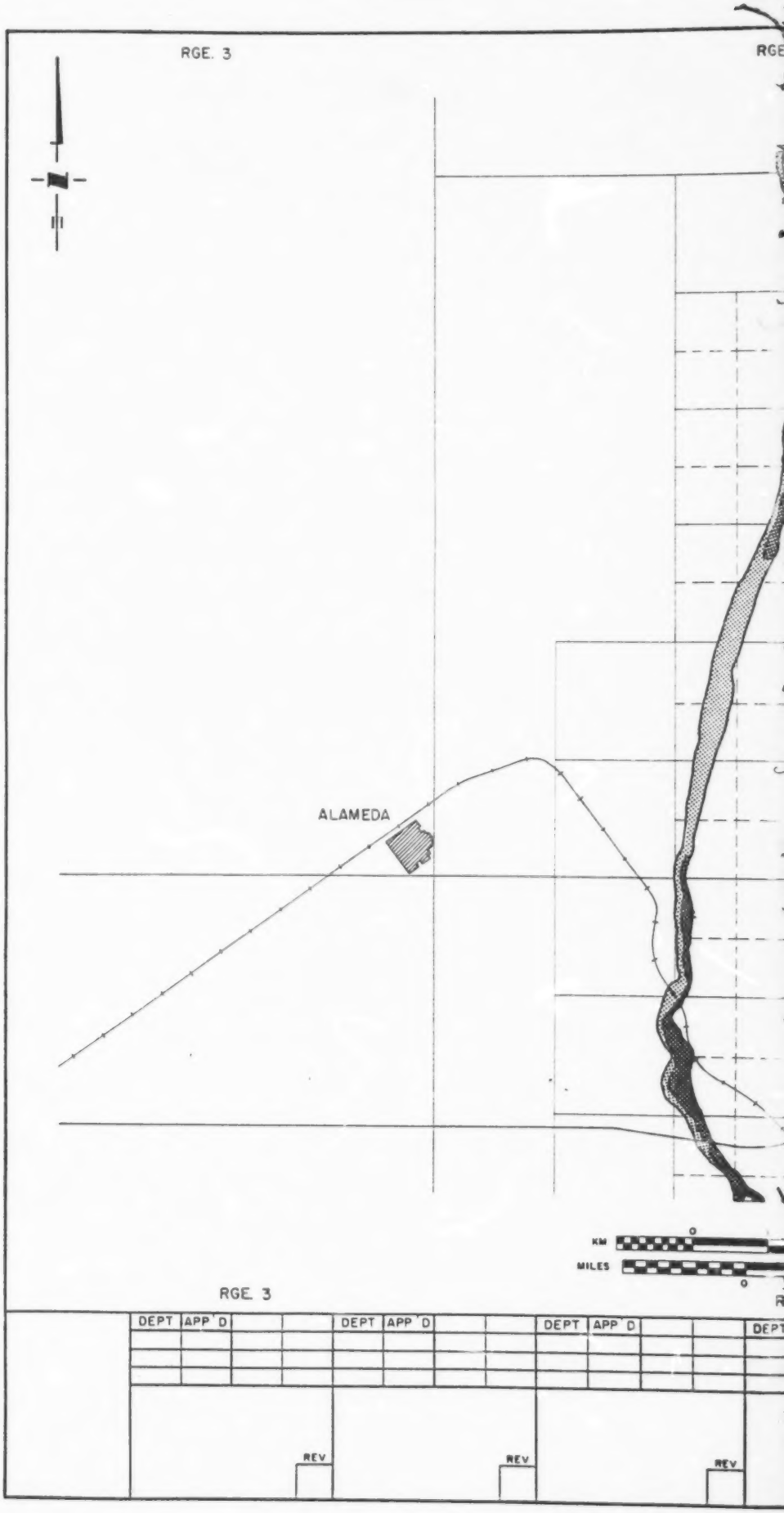
OTHER ENG. CHECKS	DRAFTING DEPT
DEPT CHK'D BY DATE	DRAWN BY J.W. CHK'D BY DATE 87-05-12
DEPT CHK'D BY DATE	SCALE:
	DESIGN DIVISION
DEPT CHK'D BY DATE	DEPT DESIGNED BY CHK'D BY
DEPT CHK'D BY DATE	APP'D BY DATE

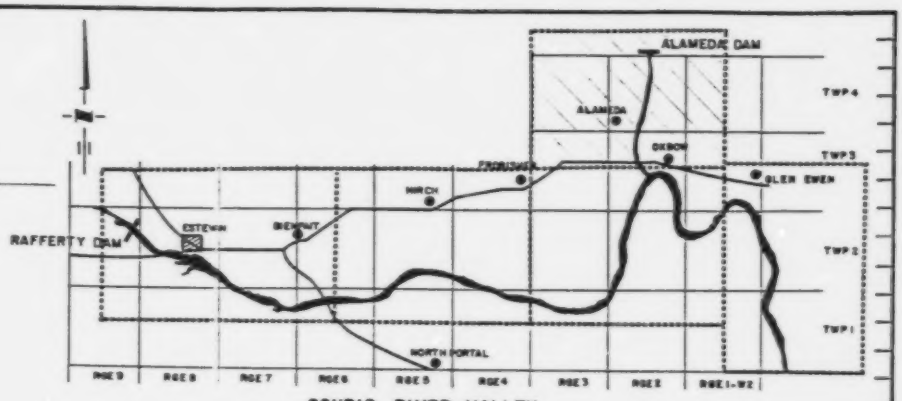
SOURIS BASIN DEVELOPMENT AUTHORITY

RAFFERTY / ALAMEDA PROJECTS

RAFFERTY / ALAMEDA DAMS
RESERVOIR
ENVIRONMENTAL IMPACT STATEMENT
IRRIGATION CAPABILITY IN THE
SOURIS RIVER VALLEY

PROP	UNIT	SYST.	FUNC	SERIAL	REV
A43	1	0	RVR	00	


RGE. 3
RGE
ALAMEDA
KM
0
MILES
0
RGE. 3
DEPT
APP'D
DEPT
APP'D
DEPT
APP'D
DEPT
REV
REV
REV



SOURIS RIVER VALLEY
KEY PLAN

LEGEND:
IRRIGATION CLASSIFICATION

CLASS 2 - GOOD; WELL SUITED FOR IRRIGATION

CLASS 3 - FAIR; ACCEPTABLY SUITED FOR IRRIGATION

CLASS 4 - POOR; UNSUITED FOR IRRIGATION DUE TO FLOODING, SALINITY, STEEP SLOPES, etc.

OXBOW

RGE. 1-W2

FIGURE 3-4

EPT	APP'D		
DRFT.		CS	87-05-14

OTHER ENG. CHECKS	DRAFTING DEPT
DEPT	DRAWN BY C. BAKER
CHK'D BY	CHK'D BY
DATE	DATE 87-05-14
DEPT	SCALE
CHK'D BY	
DATE	DESIGN DIVISION
DEPT	DEPT
CHK'D BY	DESIGNED BY
DATE	CHK'D BY
DEPT	APP'D BY
CHK'D BY	
DATE	DATE

REV. A

SOURIS BASIN DEVELOPMENT AUTHORITY

RAFFERTY / ALAMEDA PROJECTS

RAFFERTY / ALAMEDA DAMS
RESERVOIR
ENVIRONMENTAL IMPACT STATEMENT
IRRIGATION CAPABILITY IN THE
MOOSE MOUNTAIN CREEK VALLEY

PROP	UNIT	SYST	FUNC	SERIAL	REV
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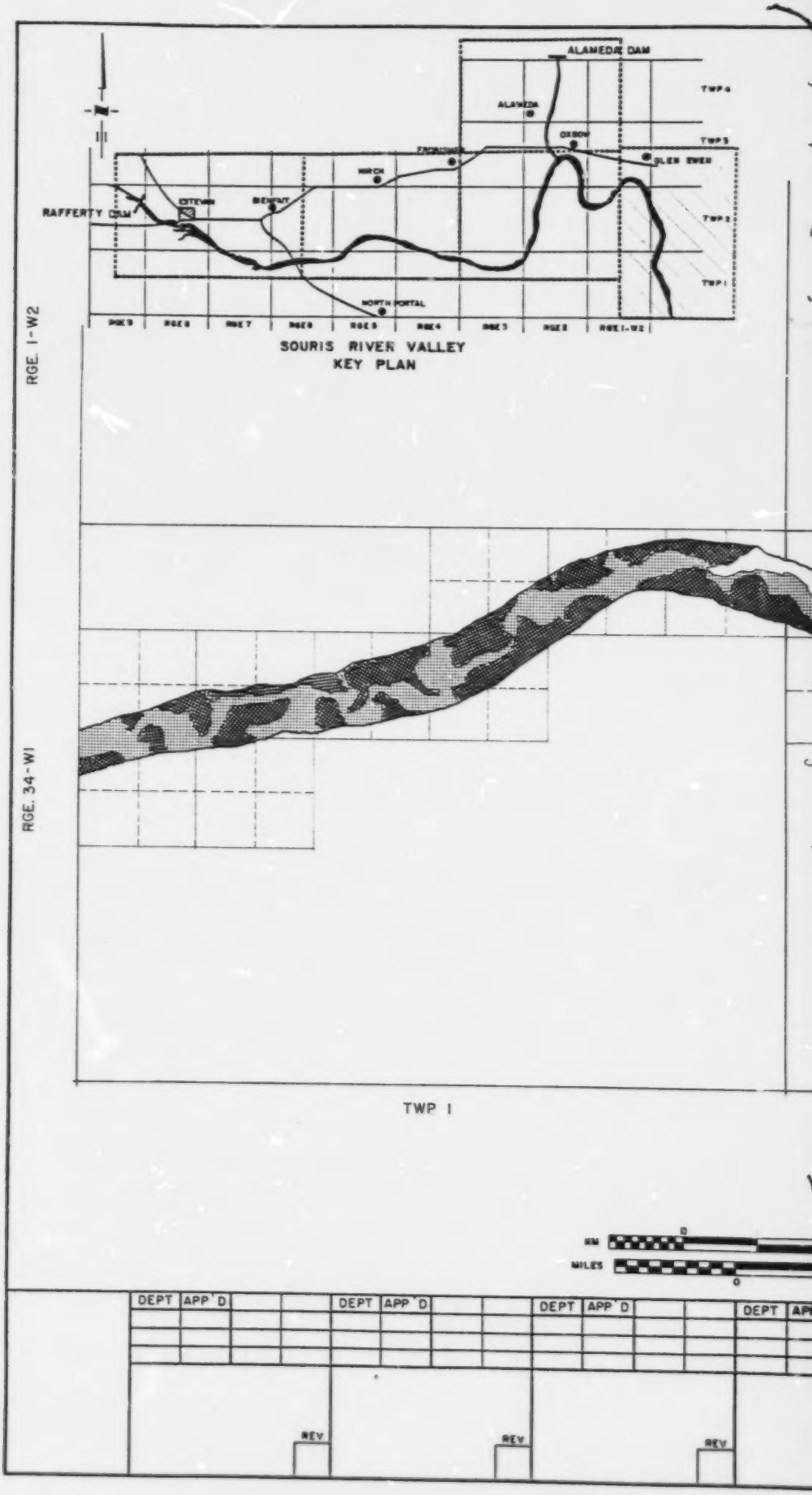
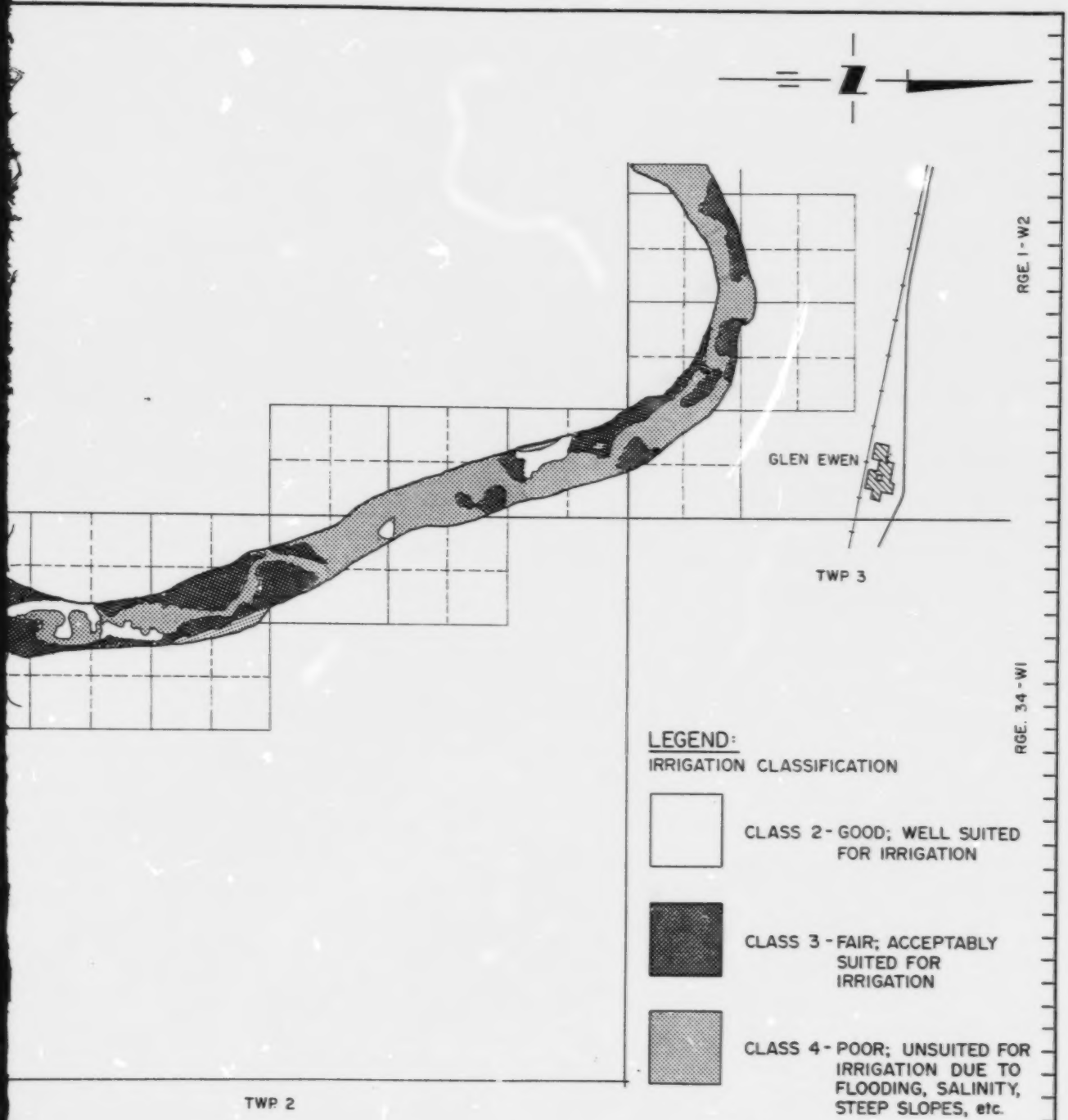

ALAMEDA DAM
ALAMEDA
OXBOW
TWP 4
TWP 3
TWP 2
TWP 1
RAFFERTY DAM
ESTEVAN
BIENFAIT
NORTH PORTAL
RGE. 1-W2
RGE. 34-W1
SOURIS RIVER VALLEY
KEY PLAN
TWP 1
KM
MILES
0
DEPT
APP'D
REV



LEGEND:
IRRIGATION CLASSIFICATION

CLASS 2 - GOOD; WELL SUITED FOR IRRIGATION

CLASS 3 - FAIR; ACCEPTABLY SUITED FOR IRRIGATION

CLASS 4 - POOR; UNSUITED FOR IRRIGATION DUE TO FLOODING, SALINITY, STEEP SLOPES, etc.

FIGURE 3-5

	DEPT	APP'D		
	DRAFT		CS	87-05-12

REV A

OTHER ENG. CHECKS
DEPT
CHK'D BY
DATE

DRAFTING DEPT.
DRAWN BY C. BETKO
CHK'D BY
DATE 87-05-12

SCALE:

DESIGN DIVISION
DEPT
DESIGNED BY
CHK'D BY
APP'D BY
DATE

SOURIS BASIN DEVELOPMENT AUTHORITY

RAFFERTY / ALAMEDA PROJECTS

RAFFERTY / ALAMEDA DAMS
RESERVOIR
ENVIRONMENTAL IMPACT STATEMENT
IRRIGATION CAPABILITY IN THE SOURIS RIVER VALLEY

PROP		UNIT	SYST.		FUNC.			SERIAL		REV.
A	43		I	O	R	V	R	0	0	A

extending north from the Souris Valley to the proposed Alameda dam site. Cameron applied the same interpretive irrigation classification system proposed by the Working Group on Irrigation Classification (1985). Both soils and landscape information were ranked into the same four general suitability classes as described previously.

In conducting the classification in the lower Souris valley, Normac kept in mind that gravity irrigation systems (border dikes, corrugations, and basins) might be the preferred type, although sprinkler systems were a viable alternative. Figure 3 shows the Souris River valley and the Irrigation Suitability Classes as determined by Normac.

There were no Class 1 (excellent) irrigable soils within the Souris River valley, because of the heavier soil texture and potential drainage problems. The Class 2 (good) irrigation soils included fairly level land areas where drainage, salinity, and flooding did not appear to be a problem.

The separation between Class 2 and Class 3 soils was not always distinct. Class 3 (fair) soils generally occupied poorer drained land areas (lower relief) or rougher land areas which might cost more to develop. Class 4 (poor) soils included those areas which were either too wet, saline, or rough (steep) to irrigate. They also included the areas of forested land near the Souris River. The land areas occupied by the Souris River and various oxbows, incoming streams and other wet areas were also rated as Class 4 (poor), but a separate tabulation of the areal extent of these wet areas was made.

The constraints used to limit Class 3 and Class 4 irrigable soils were designated by letter symbols behind the class rating. (These constraints are

not illustrated in Figure 3.) The symbols and constraints are briefly discussed below:

Symbol	Constraint	Discussion
B	Backflood	Some of the Class 4 soils west of Estevan are presently being backflood irrigated. The B symbol acknowledges this potential.
F	Forested	Land areas near the Souris River were often covered with trees. Some of these areas would be suitable for irrigation pending land clearing.
M	Manmade	These areas include cities, towns, farmyards, complexes of railways and roads or any other areas where manmade structures present obstacles to irrigation.
R	Rough	This designation was used to map areas where land leveling Topography would generally not be possible. Class 3R would be suitable for sprinkler, but generally not for gravity systems.
S	Saline	Most of the salt affected soils were west of Estevan, but some saline areas were noted east of Estevan.
U	Upslope	The symbol U was used to designate areas which were upslope adjacent to or in the River Valley. They included the buttes below Estevan and several bench areas along the River Valley.
W	Wet	Areas which appeared prone to flooding were designated with the symbol W. Some of the Class 3W land areas may be best suited for backflood irrigation.

A summary of the acreages for the various reaches of the Souris River is presented below in Table 2 (see Irrigation Suitability Map, Figure 3, for location details).

TABLE 2

Irrigation Class in Hectares (Acres)

Reach of River	Class 2	Class 3	Class 4	River* & Oxbows	Total
Rafferty to Estevan (Rge 9 to Rge 8W2)	0 (0)**	291 (718)	1,502 (3,710)	181 (446)	1,793 (4,428)
Estevan to Moose Mountain Creek Confluence at Oxbow (Rge 7 to Rge 2W2)	1,178 (2,908)	951 (2,349)	1,465 (3,618)	560 (1,383)	3,594 (8,875)
Moose Mountain Creek to U.S. Border (Rge 2W2 to Rge 34W1)	245 (605)	1,085 (2,680)	1,355 (3,346)	372 (918)	2,685 (6,631)
Moose Mountain Creek to Alameda Reservoir (Twp 3 & 4, Rge 2W2)	19 (48)	152 (375)	205 (505)	79 (196)	376 (928)
TOTAL in Hectares: (acres)	1,442 (3,561)	2,479 (6,122)	4,527 (11,179)	1,192 (2,943)	8,448 (20,862)
Percent	17%	29%	54%	14%	

* Land areas occupied by rivers and oxbows and have been included in the Class 4 irrigation suitability class.

** Area in parenthesis is in acres

Source: Normac A.E.S. Ltd., 1986.

The total Souris River valley land area (including rivers and oxbows) was 8,448 ha (20,862 acres). Class 2 soils comprised only 17% of the areas with 1,442 ha (3,561 acres). Class 3 soils occupied 2,479 ha (6,122 acres) making up 29% of the total land area. Class 4 soils comprised the remaining 54% of the area having a total of 4,527 ha (11,179 acres).

The Estevan West reach of the Souris River contained the largest percentage (84%) of Class 4 soils due to salinity and manmade structures. The Estevan to Oxbow reach contained 59% Class 2 and Class 3 irrigable soils and had the largest area of potentially irrigable land. Trends from Oxbow to the

U.S. Border were similar. Portions of the small reach of Moose Mountain Creek contained only a few narrow benches or irrigable land, 171 ha (423 acres).

ENGINEERING DESIGN AND COSTS

Based on the amount of land determined to be potentially suitable for irrigation on the uplands adjacent to the reservoirs (WRC) and downstream on the Souris River valley lowlands (Normac), it was determined that these areas represent water requirements far in excess of water supplies available for irrigation from the two reservoirs at the firm yield or 70 percent of the time. In order to evaluate which areas would most likely be developed first, WRC undertook engineering and cost estimate studies to determine the physical feasibility and areal extent of potential irrigation developments that could be supplied by the Rafferty and Alameda reservoirs. (For details of these investigations, see WRCL Report, Appendix D.)

In this component of the study, WRC utilized the soils studies classification data to delineate blocks of irrigable uplands adjacent to the Reservoirs as well as lowland areas in the Souris River valley. Annual water requirements were estimated, and application rates were determined in order to provide base data for conceptual design and for estimating costs of the distribution system.

PHOTO ONE: Section of irrigated crops utilizing central pivots. (Photo Courtesy Saskatchewan Agriculture)

PHOTO TWO: Harvesting a crop of field peas. Diversification of farm crops may be more feasible with irrigation. (Photo Courtesy Saskatchewan Agriculture)

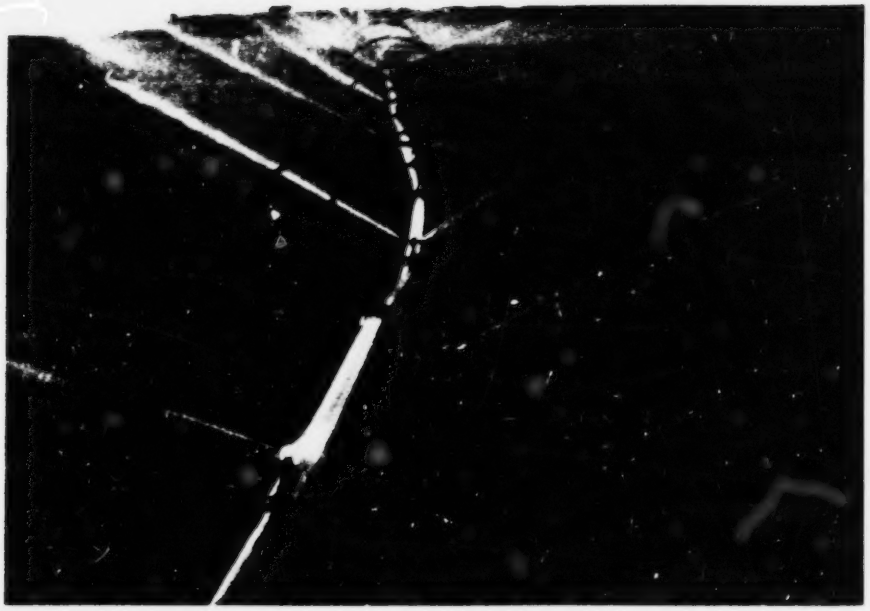


PHOTO THREE: Irrigation sprinklers near Gardiner Dam on Lake Diefenbaker.
(Photo Courtesy Saskatchewan Agriculture)

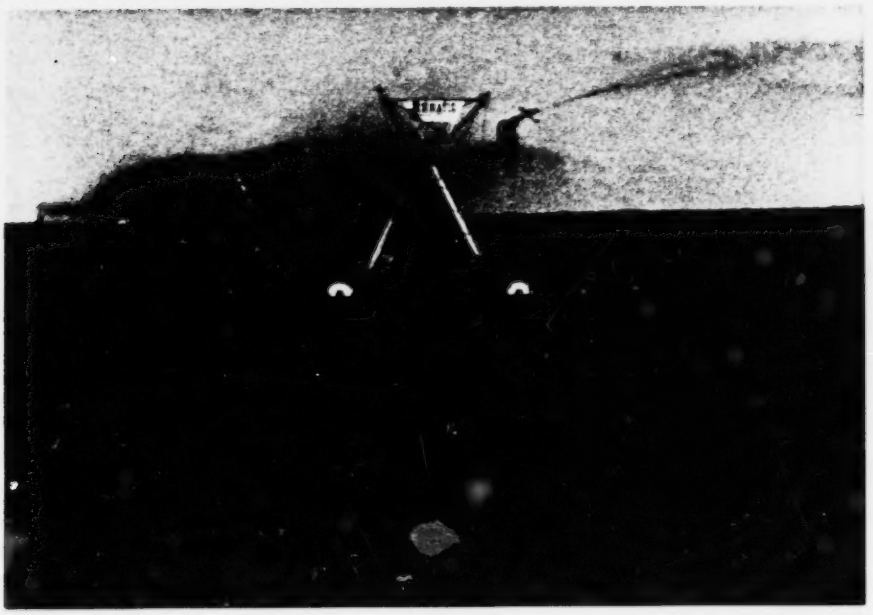


PHOTO FOUR: Central pivot irrigation sprinklers near Gardiner Dam, Lake Diefenbaker.
(Photo Courtesy Saskatchewan Agriculture)

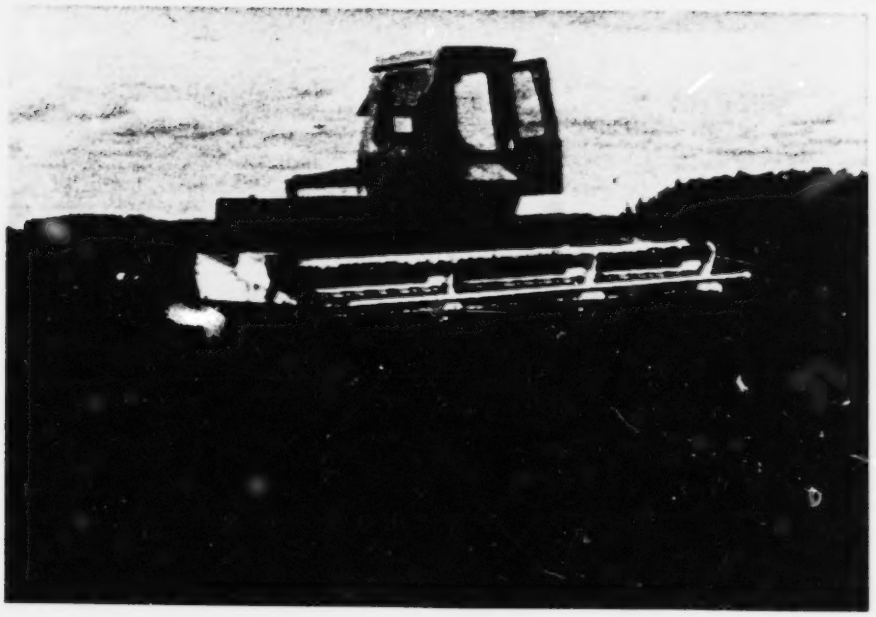


PHOTO FIVE: Cutting alfalfa field for fodder.
(Photo Courtesy Saskatchewan Agriculture)

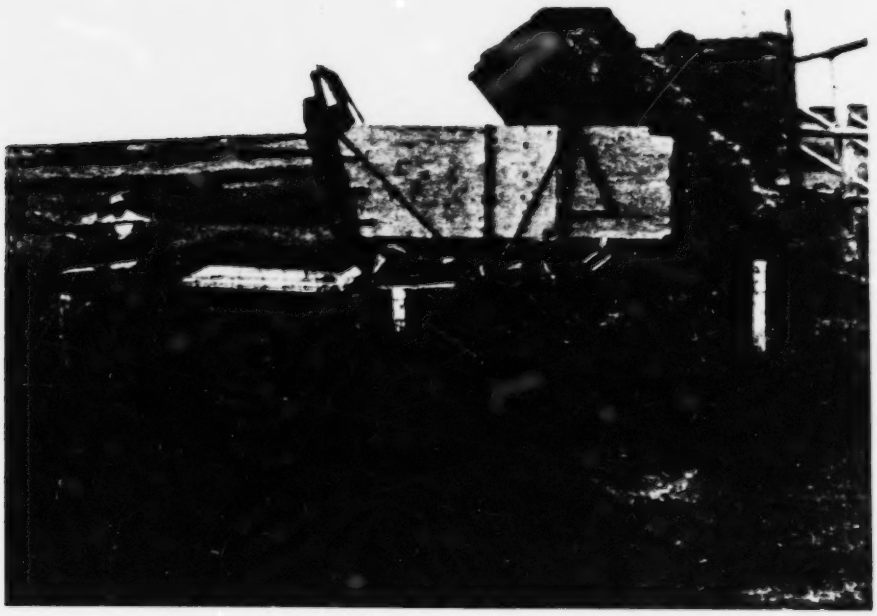


PHOTO SIX: Utilizing bale wagon to pick up and stack standard hay bales.
(Photo Courtesy Saskatchewan Agriculture)

ANNUAL WATER REQUIREMENTS

Total annual water requirements for a given acreage were derived from estimates of the actual crop irrigation demand plus the system losses. The irrigation demand is equivalent to the net crop water deficit and is the difference between the optimum consumptive requirement of the crop and the natural water supply derived from soil moisture reserves and precipitation occurring during the growing season. The total consumptive use of crops in the Study Area was estimated to be 550 mm based on an assumed mix of cereal and forage crops. Irrigation requirements in an average and peak year were determined to be 260 mm and 310 mm respectively (Table 3).

TABLE 3

Crop Water Requirements

	Requirement	Less Precipitation and Soil Reserves	=	Irrigation Requirement
Average year requirement	550 mm	290 mm		260 mm
Peak year requirement	550 mm	240 mm		310 mm

The WRC system designs and cost estimates included factors such as seepage and evaporation, operational waste such as during start-up and shut-downs, on-farm losses and leaching requirements to prevent harmful buildup of salts in the root zone. Operational wastes were assumed to be two percent to five percent, on-farm water losses 22 percent of water applied and leaching requirements a further ten percent of the actual crop requirement. A summary of the total upland irrigation water requirement is shown in Table 4. It is to be noted that peak lowland irrigation requirements are considerably less, reflecting a variety of factors including reduced evaporation, reduced operational and on-farm wastage and lower demands for leaching of salts. Lowland irrigation practices, whether by sprinkler or by other means will also likely result in less return flow to the Souris River than originally assumed

in the WRC modeling. Also, with pipeline distribution of water in the Alameda upland areas, and sprinkler irrigation with no return ditches, there will be much less impact on downstream Souris River water quality than what could occur with open land delivery and return flow systems. For water requirement calculations, whereas 450 mm (18 inches) have been assumed as peak annual demand for upland irrigation, 300 mm (12 inches) has been assumed as the peak demand for lowland irrigation. These water requirements correspond closely with current Saskatchewan Water Corporation irrigation water licensing policy.

TABLE 4

Upland Water Requirement Summary

Water Requirement	Average Year	Peak Year
Irrigation Demand	260 mm	310 mm
Seepage and Evaporation from canals and pipelines	negligible	negligible
Operational waste	20 mm	10 mm
On-farm losses	80 mm	100 mm
Leaching	30 mm	30 mm
TOTAL REQUIREMENT	390 mm	450 mm

A 450 mm water requirement translates into a ratio of 4.5 cubic decametres (dam^3) per hectare annual water requirement. In other words, a 1,000 dam^3 water supply would provide for irrigating 222.2 ha or 550 acres. The 32,970 dam^3 previously estimated by WRC as being available for irrigation would therefore be sufficient to irrigate 7,326.7 ha (18,104 acres).

In order to develop cost curves for upland irrigation developments, WRC investigated three sizes of irrigation blocks adjacent to each reservoir. They also assumed full irrigation of all Class 2 valley lowlands. Conceptual designs were prepared for each irrigation development scenario. Upland development alternatives included a main pumpstation at the reservoir, a discharge line, a distribution system utilizing either line canals or pressure pipelines, and on-farm irrigation works. For the lowlands, a series of rock

weirs were proposed within the Souris River channel. Individual pump stations located along the in-channel storage created by the weirs would supply water to the individual irrigation parcels. (This system is similar to that in use in the Lumsden-Craven-Fairy Hill reach of the Qu'Appelle Valley.)

Capital cost estimates were prepared for each of the different block sizes and locations. Annual costs were calculated based on operating costs, maintenance and energy costs to operate the systems. All costs were broken down by components such as main pumpstation, distribution system and on-farm works.

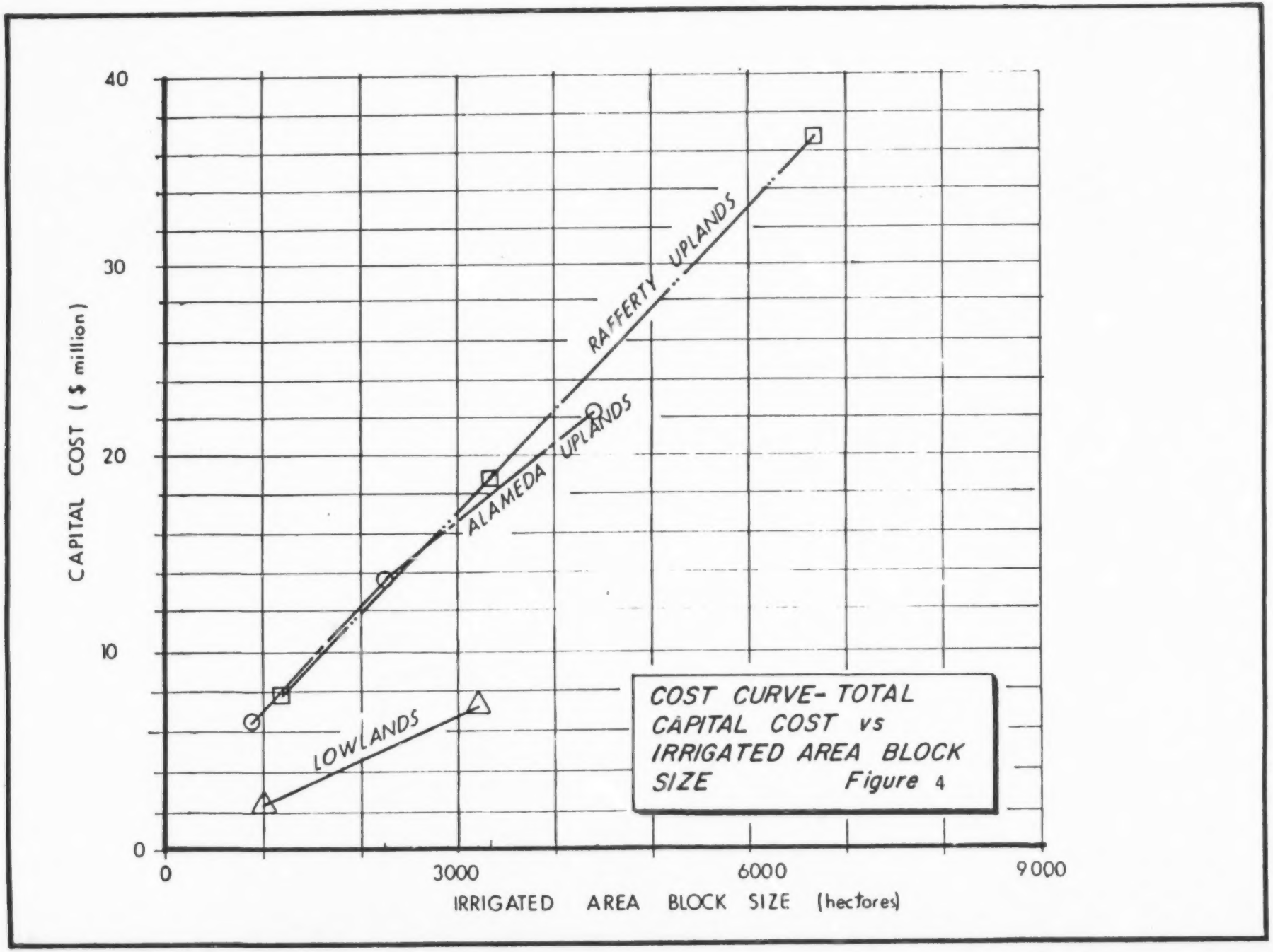
As shown in Figures 4 and 5, the capital costs of developing the valley lowlands are less than half the costs of upland irrigation. Annual cost estimates are similarly much lower (Figure 6). With these cost estimates it is apparent that priority should be given to development of the Souris Valley lowlands irrigation potential.

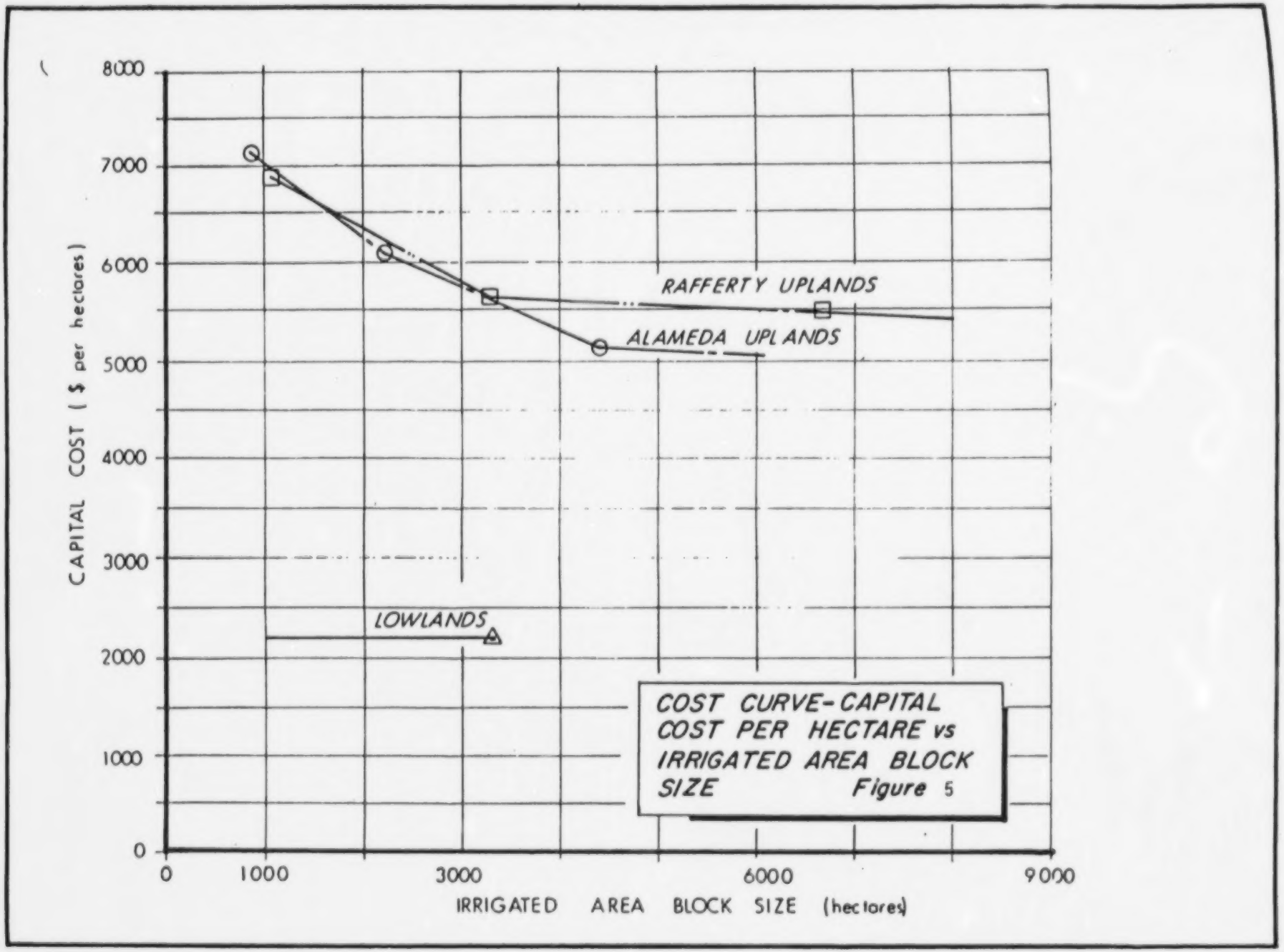
ECONOMIC EVALUATION OF IRRIGATION

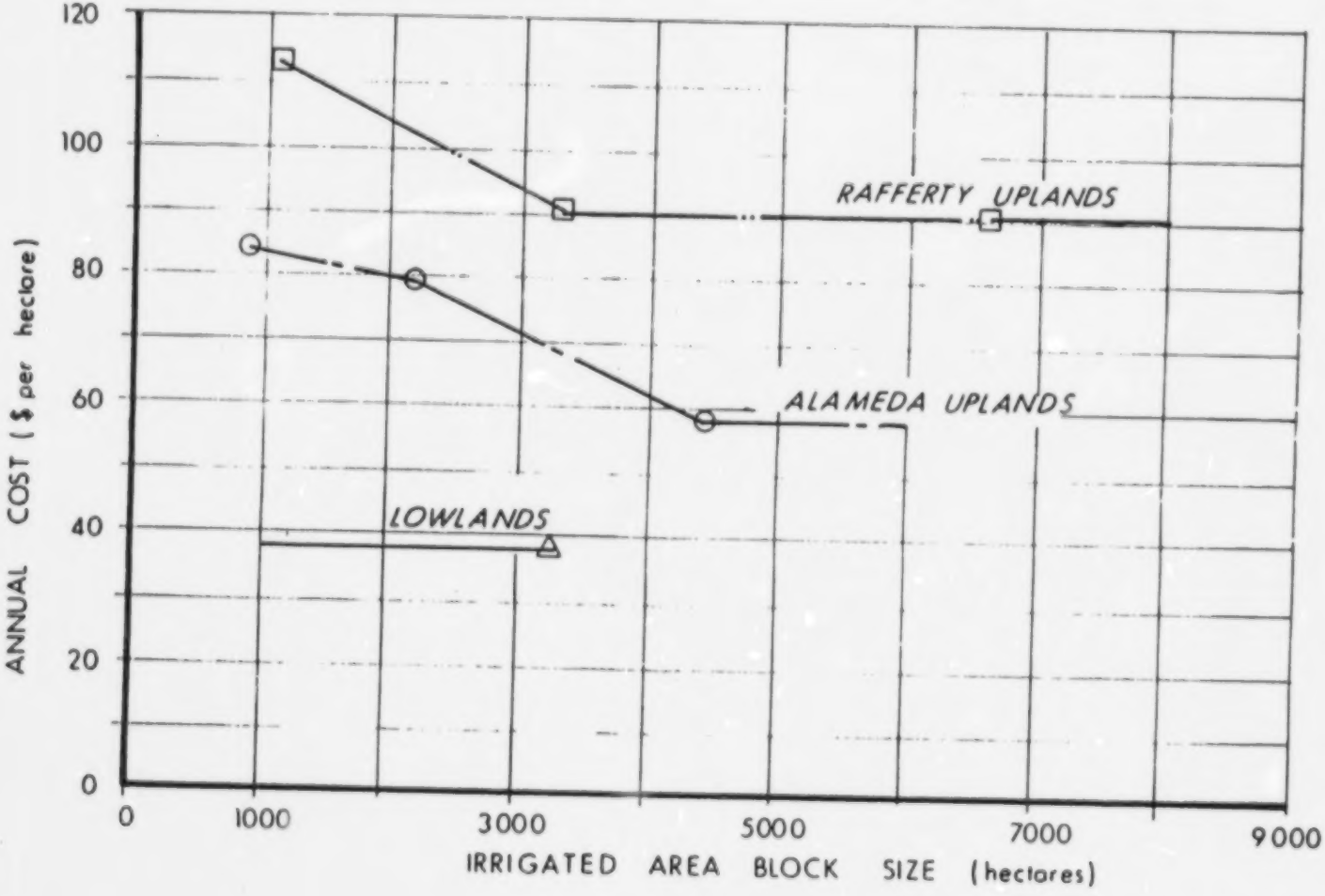
As indicated in the Social and Economic Circumstances Section of this Environmental Impact Statement, the economy of the Study Area is predominantly agriculture based. Lack of new economic opportunities in the rural areas has caused many rural people to migrate to larger urban centres. Even in urban centres, there appears to be a trend for youth to migrate outside the Study Area, leaving a growing proportion of elderly in those centres.

The WRC Study utilized a number of economic development scenarios. The lowland production scenario assumed a two-thirds/one-third ratio of grain and livestock farms. The grain production scenario contained 63% grain farms, 12% livestock farms and 25% specialty farms. The livestock production scenario assumed 80 livestock farms and 20% grain farms. An aggressive development scenario, based on the experience of southern Alberta irrigation development assumed 70 percent livestock farms, 22 percent specialty crop farms and eight percent grain farms.

Results of the water users' financial analysis (WRC) indicated that in the long run it would be advantageous to convert from dryland to irrigated production. The analysis also indicated that established farms would benefit more than beginning farmers with low equity. Furthermore, as irrigated farms


40
30
20
10
0
CAPITAL COST ($ million)
0
3000
6000
9000
IRRIGATED AREA BLOCK SIZE (hectares)
RAFFERTY UPLANDS
ALAMEDA UPLANDS
LOWLANDS
COST CURVE- TOTAL CAPITAL COST vs IRRIGATED AREA BLOCK SIZE Figure 4


8000
7000
6000
5000
4000
3000
2000
1000
0
CAPITAL COST ($ per hectares)
RAFFERTY UPLANDS
ALAMEDA UPLANDS
LOWLANDS
0
1000
3000
6000
9000
IRRIGATED AREA BLOCK SIZE (hectares)
COST CURVE- CAPITAL COST PER HECTARE vs IRRIGATED AREA BLOCK SIZE Figure 5



COST CURVE-ANNUAL COST PER HECTARE vs IRRIGATED AREA BLOCK SIZE Figure. 6

have a much higher investment per hectare, higher interest rates would discourage the adoption of irrigation in the Study Area.

As different projects require different levels of investment, benefits generated also vary from project to project. The WRC benefit-cost ratios for the irrigation development scenarios ranged from 0.621 up to nearly 2.6 depending on the economic scenario. The lowland irrigation production scenarios produced the most favorable economic returns on investment. (For details on the relative economic evaluation of the various scenarios, see the WRC Report, Appendix F.)

Economic studies showed that the present worth for each hectare of irrigation to be developed would range from a low of about $4,547 per hectare to in exess of $17,880 per hectare.

WRC concluded that providing water for only 70 percent of the time would allow irrigation development from a minimum of 3,900 ha (9,637 acres) to a maximum of nearly 9,100 ha (22,486 acres). It was assumed that the first 3,237 ha (8,000 acres) or irrigation would be developed in the lowlands along the Souris River, since this is the least cost alternative at $2,216 per hectare ($1985). Combinations of developments along the river valley bottom and on the uplands ranged in cost from $3,133 per hectare to $4,444 per hectare. Cost estimates for upland irrigation alone ranged from a low of $4,940 per hectare at Rafferty to $7,175 per hectare at Alameda.

Irrigation of the lowland areas was estimated by WRC to require costs of $7,172,300 for an average cost of $2,216 per hectare (Table 5). These costs would be made up of $307 per hectare for the river control works, $1,372 per hectare for on-farm works and $537 per hectare for other costs. The Alameda block development would require more intensive capital costs as a main pumpstation and distribution system are required. At the largest scale of development, costs of $5,045 per hectare are estimated - $816 for the pumpstation, $1,586 for distribution, $1,420 for on-farm works and $1,223 for other costs. At a half scale of development, per hectare costs would increase by 20%. Overall, due to the above cost efficiencies, development priority is expected to be placed on lowland development. Constraints to development in the lowlands will be posed by irregular shaped plots of limited size which will result in difficulty using automated sprinkler systems. Costs of development would be a combination of public and private investment.

TABLE 5

Capital Cost Estimate for Probable Irrigation Scenario

	LOCATION			
	Lowland	Alameda		
Irrigated Area H.a	3,237.0	4,436.0	2,218.0	887.0
Cost (in thousands)				
- Main Pumpstation	993.6*	3,618.7	2,867.4	1,977.5
- Distribution System	-	7,036.7	4,439.1	1,682.9
- On Farm**440.0	4,440.0	6,299.7	2,903.3	1,161.2
- Other***	1,738.7	5,425.6	3,267.2	1,542.9
TOTAL	7,172.3	22,380.7	13,447.0	6,364.5
Cost per Hectare	2,216.0	5,045.0	6,063.0	7,175.0

* For river control works

** Includes drains, sprinklers, and pumps only

*** Contingency (20%) and engineering (10%)

Source: Water Resource Consultants Ltd. Rafferty and Alameda Reservoirs Conceptual Evaluation of Irrigation and Recreation Costs and Benefits. Volume II. Appendix F, Irrigation Economics Evaluation.

RECENT IRRIGATION PROJECTIONS

Since the WRC Study in 1985, the Saskatchewan Water Corporation and the Souris Basin Development Authority have re-evaluated irrigation optimization related to the Rafferty and Alameda Projects. As a multi-purpose project, a realistic balance must be struck between the various potential users of available water. When the project was first conceived, Saskatchewan Power Corporation had envisaged wet-cooling one 300 megawatt unit utilizing Rafferty reservoir water. With the relocation of the Rafferty dam site 4 km further southeast, the diversion channel between Boundary Reservoir and Rafferty was developed as part of the Project. Further, it was initially deemed desirable to irrigate as much of the Souris Valley lowlands as possible. Saskatchewan

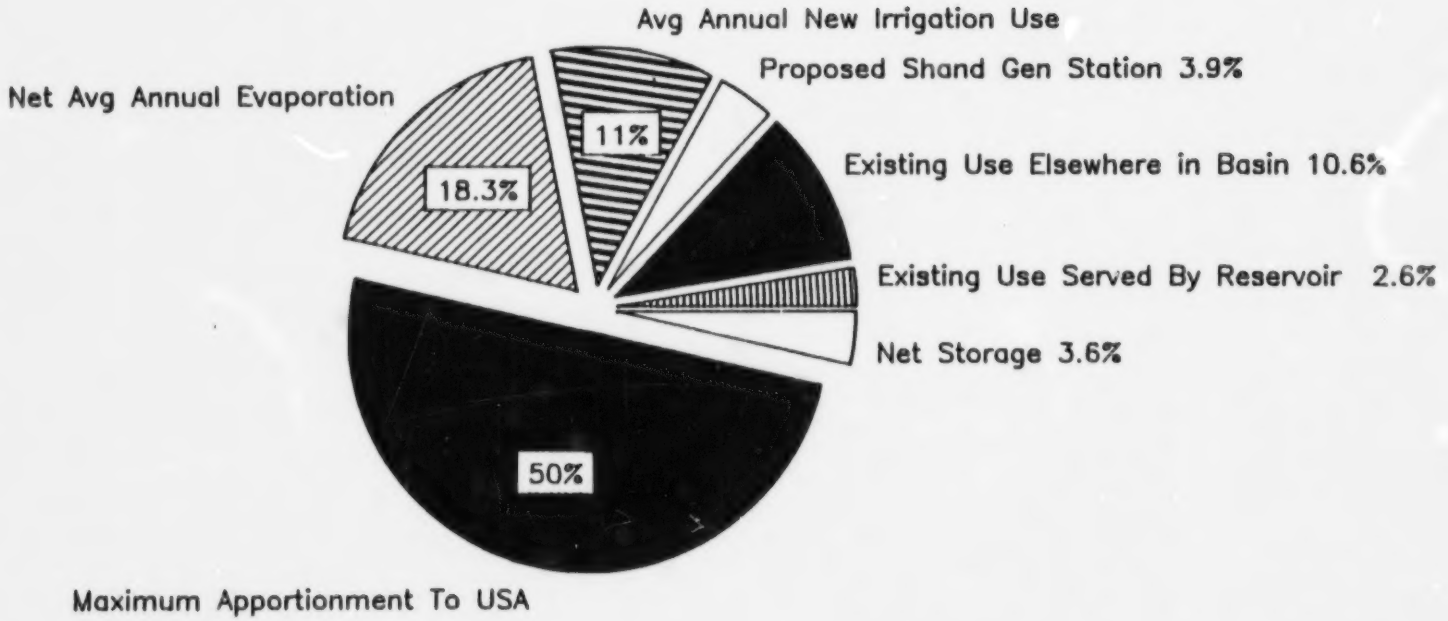
Power Corporation originally assumed that there would be insufficient water to cool two 300 megawatt units (its desired cooling option) but recent advances have altered that assumption. Detailed design and cost investigations have determined that approximately 6,400 dam^3 of water would be required annually to water cool two 300 megawatt units running at an 80 percent capacity factor. A method of water treatment is now proposed which gives Saskatchewan Power Corporation the ability to treat and re-use waste water, thereby eliminating the need for any discharges into the Souris River. This method of water treatment at Shand eliminates the need for certain evaporation ponds and reduces their per unit water requirements. It also enables SPC to utilize effluent from the Estevan sewage lagoons (1,500 dam^3/yr) as an additional source of cooling water. With cooling towers to transfer waste heat to the atmosphere, SPC now estimates that approximately 4,640 dam^3 of water from the Rafferty Reservoir would be sufficient to cool both 300 megawatt units (Saskatchewan Power Corporation pers. comm., 1987).

Considering the history of irrigation uptake elsewhere in Saskatchewan, and particularly in the Lake Diefenbaker area, the Souris Basin Development Authority, came to the position that the projected 7,285 ha (18,000 acres) of irrigation associated with the estimated 32,970 dam^3 of available water was too optimistic. Further, with current depressed agricultural commodity prices and no change in these low prices yet foreseen, development of upland irrigation at either the Rafferty or Alameda areas is likely to be slower than previously estimated by WRC.

With Saskatchewan Power Corporation having an almost immediate need for cooling two 300 megawatt units at Shand, it became economically and strategically desirable to reduce the total forecast irrigation from 7,285 ha (18,000 acres) to 4,855 ha (12,000 acres). This projection assumed 3,240 ha (8,000 acres) of irrigation in the Souris valley lowlands, 2,025 ha (5,000 acres) from Rafferty and 1,215 ha (3,000 acres) from Alameda. The remaining 1,615 ha (4,000 acres) of irrigated land was assumed to be upland irrigation in the Alameda Project Area. Figures 7 and 8 illustrate the projected water use from the Rafferty and Alameda Reservoirs with 50 percent and 40 percent apportionment to the United States. The lower apportionment provides a greater net storage.

Water Use Rafferty & Alameda Reservoirs

(Percentages Are Based Upon an Average Annual Flow
Of The Souris River At The U.S. Boundary = 120,000 dam3)

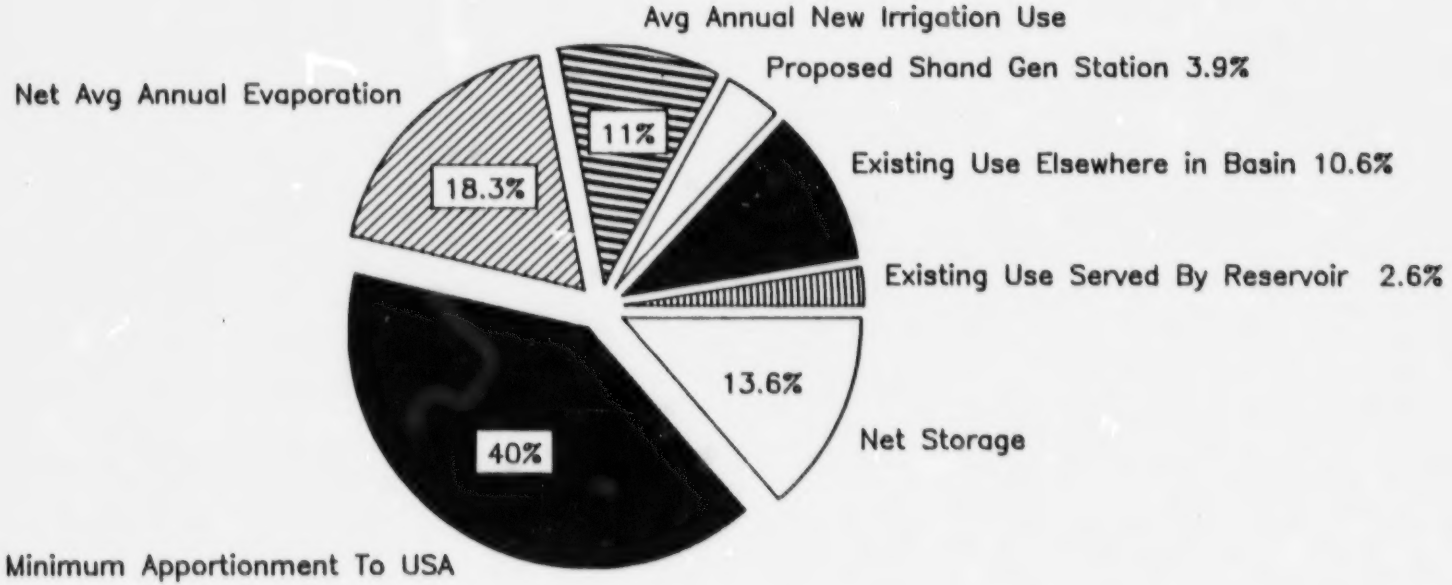


Source: Sask Water Corporation; 1987

FIGURE 7

Water Use Rafferty & Alameda Reservoirs

(Percentages Are based Upon an Average Annual Flow
Of The Souris River At The U.S. Boundary = 120,000 dam3)



Source: Sask Water Corporation; 1987

FIGURE 8

SUMMARY AND CONCLUSIONS

Agriculture is one of the important beneficiaries of the proposed multi-purpose Rafferty and Alameda Projects. Agricultural opportunities are presently limited by the sub-optimal rainfall during the growing season in most years. Some irrigation is occurring in the basin now, mostly as a fodder base for livestock operations in the area. The majority of existing irrigation in the Rafferty project area occurs in the R.M. of Estevan; there is no significant irrigation in the Alameda area.

Available water for irrigation is limited as most of the stream flow on the Souris River and its tributaries occurs during spring runoff. Flows are highly variable with extreme flows and floods some years and little or no flows in others. The Rafferty and Alameda reservoirs will provide more reliable supplies during periods of high irrigation demand and allow for significant increases in potential irrigated land.

The uplands surrounding the Rafferty Reservoir are generally of marginal quality. Irrigability indices indicate that most of the land has fair to poor potential for irrigation development. The uplands surrounding the Alameda Reservoir are generally better suited to irrigation. The valley bottom lands in the Souris Valley downstream of the reservoirs indicate the most favorable potential for irrigation. This good to fair potential relates to soil capabilities and topography as well as to lower capital and operating costs. Although these bottom lands are limited in size and irregularly shaped due to topography and meandering of the Souris River, they require relatively low cost lift pumps from the in-stream storage ponds created by a series of rock weirs. These non-intensive irrigation areas will be the least costly and likely the first to develop.

Irrigation development scenarios prepared for the Authority indicate that the lowland irrigation areas would provide the greatest economic return on investment.

4,855 ha (12,000 acres) of irrigation are projected with two-thirds of this in the Souris River lowlands and one-third in the Alameda uplands. Although upland irrigation in the Rafferty project area is physically feasible, very little, if any, is anticipated there in the foreseeable future.

It has been determined that a 100 percent firm yield of water is neither necessary nor desirable (see Agriculture section of Benefit-Cost Analysis in this Environmental Impact Statement). Availability of irrigation water 70 percent of the time enables a six fold increase in the potential irrigable area.

As there is much more irrigable land in the Project Areas than there will be available water, only the best lands are anticipated for irrigation development. According to the WRC Report, there are in excess of 18,300 ha of Class 2 (good) potential in the Rafferty area, and in excess of 31,400 ha of Class 1 and Class 2 irrigable land in the Alameda area. Although the land may be physically suitable for irrigation, economic feasibility will dictate if or when the development of these lands actually takes place. WRC estimated 3,846 ha of Class 2 and 2,564 ha of Class 3 irrigable lands in the Souris Valley lowlands however a more detailed investigation by Normac reduced the estimate to 1,442 ha of Class 2 lands and 2,479 ha of Class 3 lands. It is assumed that these lands will be among the first to be irrigated with Rafferty water. It is to be noted that there should be no need for conflicts between wetlands, oxbows, and forest lands adjacent to or within meanders of the rivers. These lands were all deemed to be Class 4, either poor or unsuitable for irrigation.

It is further to be noted that the lowland irrigation requires less water in an average or peak year. The Saskatchewan Water Corporation has advised that whereas 450 mm (18 inches) of irrigation water is required in peak years in upland areas to account for on-farm and distribution losses, wastage and leaching as well as the crop needs, 300 mm (12 inches) of irrigation water is necessary on lowland irrigation plots. This results in a greater net return in the lowlands relative to the irrigation water requirements.

As the estimates for potential irrigation have been based upon existing soil classifications, maps and topographic information, the Authority recognizes that additional soils and related water quality research and analysis must be undertaken to determine precisely which lands are most suited to irrigation. This will be necessary to ensure maximum benefit from irrigation investments. Such research should include additional soil testing for nutrients, boron, mercury and other metals and inventory mapping to ensure that landowners become fully aware of relative potential. As Saskatchewan

Agriculture and the Saskatchewan Water Corporation are already involved in similar programs elsewhere in the province, these agencies should take the lead role in this endeavour and in promoting irrigation farming in general. With so many factors to consider, it is difficult to accurately predict which farmers will switch to use of irrigation, or when. In fact, irrigation uptake rates are currently the focus of a broader investigation by federal and provincial agencies. On farm irrigation development is not foreseen as a responsibility of the Souris Basin Development Authority, now or in the future. While not the direct proponent of irrigation, the Authority does, however, recognize the need for accurate pre-impoundment baseline information on soils within the reservoir areas.

Any new irrigation development would obviously be subject to the availability of water in the reservoirs. Additional downstream irrigation from the Rafferty reservoir, for example, will not be licensed until the reservoir reaches the minimum working supply level of at least 543 m. There is a 70 percent probability of filling the reservoir to that level within five years and an 82 percent probability of filling the reservoir to elevation 543 m within ten years (see Surface Hydrology section, Figure 3.14).

In conclusion, the Rafferty and Alameda reservoirs will create new irrigation and farm diversification opportunities which would otherwise not be possible. Irrigation of 4,855 ha (12,000 acres) of high quality land will lead to improved and more reliable productivity in the Study Area compared to the productivity of the more extensive but poorer quality lands being inundated. As a multiple purpose water-management project, agriculture is one of the important components which will be able to take advantage of the new found retention of Saskatchewan's Souris Basin water. Water has an added value in use, regardless of its type of use. Without the means to store the irregular Souris Basin water, future irrigation potential will remain non-existent. Saskatchewan will now have the opportunity to make use of this precious resource to improve and diversify the agricultural industry.